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FROM

G. H. Holliday,
of Cambridge.

12 Feb., 1891.

b. d. – 4, 2d sess. (1882-83.) Senate.

REPORT

OF

THE SELECT COMMITTEE

ON

HEAVY ORDNANCE AND PROJECTILES

APPOINTED UNDER

SENATE RESOLUTION OF AUGUST 2, 1882.

Senator JOHN A. LOGAN, Chairman.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1883.

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47TH CONGRESS, 2d Session. } SENATE. { REPORT No. 969.

IN THE SENATE OF THE UNITED STATES.

FEBRUARY 9, 1883.—Ordered to be printed with the testimony.

Mr. LOGAN, from the Select Committee on Heavy Ordnance and Projectiles, submitted the following

REPORT AND TESTIMONY:

The Select Committee on Heavy Ordnance and Projectiles, having been directed to report under the following resolution—

Resolved, That a select committee of five Senators, to consist of the chairman of the Committee on Military Affairs, and of Naval Affairs, and three other Senators to be appointed by the President *pro tempore* of the Senate from said committees, be raised, with instructions to take into consideration the subject of heavy ordnance and projectiles for the armament of the Navy and the sea-coast defenses, and said select committee shall have leave to sit during the recess of the Senate and to send for persons and papers, and shall report the results of their investigations to the Senate at its next session, with any recommendations said committee may deem it proper to make on the subjects committed to them--

Made public announcement that it would hear and receive the statements of all persons interested in the subject of heavy ordnance and projectiles, who desired to present their views for the consideration of the committee.

A number of inventors and manufacturers of cannon and projectiles, and the Chief of Ordnance of the Army, appeared before the committee and gave expression to their views while submitting plans, designs, and estimates. Their statements, designs, &c., accompany and form part of this report. The committee also examined the report, submitted to Congress last summer, of the board of officers appointed to consider the subject of heavy ordnance and projectiles, under the act of Congress approved March 3, 1881, of which board Gen. George W. Getty, United States Army, was president.

After as careful a consideration of this very important subject as the time at its disposal would permit, the committtee desires to state, in brief, the conclusions it has reached as to the most judicious and economical method of meeting the heavy-ordnance question in the future.

It appears from the statements made to the committee by the Chief of Ordnance, United States Army, that the government has on hand a large number of comparatively inefficient 10-inch smooth-bore guns, but that these guns admit of being converted into strong and effective 8-inch rifles, by lining them with a coiled wrought-iron tube, which also carries the rifling. The endurance of these 8-inch rifled guns is fully proved from the records, which show that they have been fired many hundreds of rounds, and are still in good condition.

Their power has been demonstrated by trials against iron plates, showing that a penetration of from 8 to 10 inches is obtained at 1,000 yards. By converting several hundred of these smooth-bore guns we shall at once utilize material on hand, secure at a comparatively low

cost a gun that is well adapted to the defense of secondary positions, our smaller sea-ports, and very effective for the protection of torpedo fields. With the like object of making the most of the material now on hand, the 300 15-inch smooth-bore guns distributed at our forts should be placed in a serviceable condition by being mounted on carriages adapted for firing the present charges of powder. There are a sufficient number of carriages on hand for mounting most of these guns, but many of them need alterations to facilitate maneuver, and the addition of buffers to check recoil under the new condition of a largely increased powder charge.

The committee is impressed with the necessity of employing steel in some form, as the material of guns of high power and of large caliber. This metal seems now to be almost universally adapted for ordnance purposes abroad, and in order to compete with foreign powers, as regards both the guns and armor plate that can be brought against us, as soon as practicable we, too, must have recourse to steel as the material for our guns. For which reason, and with a view to making a beginning in this important work of developing the manufacture of steel guns in this country, the recommendation of the Chief of Ordnance that some experimental all-steel guns of the smaller caliber should be constructed for test is accepted. Experiments in this direction will be beset with many difficulties owing to the backward state of our steel industries as regards the production of gun steel, from the want of adequate plant, knowledge of manufacture, and experience in the mechanical construction of built-up guns. The embarrassment we may reasonably hope will in time disappear under proper encouragement and with an increased experience in the manufacture.

It will take time before such a development of our manufacturing facilities is attained as will admit of our producing steel guns of the largest calibers, such as will be required for coast defense; but we can do something even now in the way of the smaller calibers, and thus make a beginning. The earlier we make a beginning, just so much earlier shall we reach that ultimate development requisite.

It is apparent that cast iron alone is not equal as a material to steel for modern rifled guns. The almost universal practice of Europe is against it. But where properly strengthened with steel, by hooping, tubing, or wrapping with wire, cast iron may yet be employed to excellent purpose, and especially with rifled mortars, when the strains to be endured are not great.

The recommendations of the Chief of Ordnance, in reference to the fabrication of certain experimental guns of this kind, are both wise and prudent, as these guns can be produced with comparatively little delay, the metal could be procured at once in this country, and we could thus be provided with a very effective gun, at least one that will surpass anything we now have. We shall thus be better prepared for emergencies until the developments of steel manufacture furnish us with more powerful all-steel guns. As regards the various systems of breech-closure for breech-loading guns, the two now in general use, the interrupted screw and the Krupp wedge-block, seem preferable to any of the other systems yet tried. They are simple in construction and have satisfactorily endured the tests of actual service. They have been tested not in single guns experimentally, but in guns in actual service, and in guns of all calibers, from the small field gun, weighing less than half a ton, to the monster guns of 72 and 100 tons. This being a fact, combined with the further fact that the method of making and applying these two systems in gun-construction is known in the minutest detail

for purposes of manufacture, having gone beyond the region of experiment, is the strongest argument in favor of using these in our constructions. The new systems of breech mechanism proposed, however, seem to have merit, but not such pronounced merit as so justify the expenditure of large sums in their trial prior to the commencing of fabricating guns on one or the other tried systems.

In the opinion of the committee, therefore, one of these two systems should be used at the present. But inasmuch as there are various opinions on the subject of metal for ordnance purposes, and also as to the best systems of guns and projectiles, entertained by persons of vast experience in these matters, and also that inventors may have a fair opportunity of having their inventions tested, where they promise success, your committee make the following recommendations:

We recommend that the Chief of Ordnance have, as fast as practicable, one hundred of the 10-inch smooth-bore cast-iron guns converted into 8-inch rifle muzzle-loading guns, with the coiled wrought-iron tube, which shall carry the rifling.

We recommend that the 300 15-inch smooth-bore guns, distributed at our forts, shall be placed in a serviceable condition by being mounted on carriages adapted for the firing at the present charge of powder, with the addition of buffers to take recoil under the new condition of a largely increased powder charge.

We recommend the making of two steel guns; one 8-inch, and one 10-inch; both to be rifle breech-loading guns.

We recommend the making of two cast-iron rifle breech-loading 12-inch guns, for the purpose of thoroughly testing that quality of gun.

We recommend the making of such number of cast-iron guns banded with steel bands or wrapped with wire, as may be necessary to fully and thoroughly test their efficiency.

We recommend that the views of the Chief of Ordnance and Getty Board be carried out in reference to the fabricating of 12-inch rifled mortars.

We recommend that the Chief of Ordnance shall select from the many breech-loading devices offered to the Getty Board and Committee on Ordnance two that promise the greatest success; and shall have them tested at a cost to the government of not more than fifteen thousand dollars each.

We recommend that the Chief of Ordnance may test any of the various projectiles offered, at as small a cost to the government as can be done; selecting such projectiles as in his opinion promise the greatest success.

We recommend that the Chief of Ordnance test the system known as the "multicharge" system of guns.

And, for the purpose of carrying out these recommendations, and to enable the Chief of Ordnance to prosecute the work in a judicious and economical manner, that the sum of $500,000 be appropriated in the fortification bill for use during the fiscal year ending June 30, 1884; and the Chief of Ordnance will report, through the Secretary of War, at the next session of Congress, the progress made in carrying out these recommendations.

All of which is respectfully submitted.

JOHN A. LOGAN, *Chairman.*
WADE HAMPTON.
E. H. ROLLINS.
CHAS. W. JONES.

STATEMENTS

BEFORE

THE SELECT COMMITTEE ON HEAVY ORDNANCE AND PROJECTILES,

APPOINTED UNDER SENATE RESOLUTION OF AUGUST 2, 1882,

CONSISTING OF

SENATORS LOGAN (CHAIRMAN), CAMERON OF PENNSYLVANIA, ROLLINS, HAMPTON, AND JONES OF FLORIDA.

WASHINGTON, *Saturday, December* 23, 1882.

The committee met pursuant to notice, to hear statements from persons interested in the subject of heavy ordnance and projectiles.

STATEMENT OF W. E. WOODBRIDGE.

WASHINGTON, *January* 27, 1883.

To the Hon. Committee of the Senate on Heavy Ordnance and Projectiles:

GENTLEMEN: I have the honor respectfully to refer to the appended pages for a description of the plans of gun-construction presented by me to the late Board on Heavy Ordnance and Projectiles.

In connection therewith I submit a summary of the principal dimensions, charges, calculated energies, and estimated cost of the proposed guns.

The systems recommended by the Board referred to will be found described in sections 2, 4, and 5.

I beg to state that it will be a pleasure to me to in any way further the objects of the committee.

I am, gentlemen, very respectfully, your obedient servant,

W. E. WOODBRIDGE.

MODES OF CONSTRUCTING HEAVY ORDNANCE PROPOSED BY W. E. WOODBRIDGE.

The several systems of construction herewith submitted are not presented as being equally advantageous for guns of high power, but the endeavor has been to present the best development of the different classes of construction which have yet a possible foothold in the estimation of constructors of ordnance.

If this can be done, it seems to be the way in which the comparative merits of different systems will best be made to appear. And if there are positions for guns of a second class, the study of the construction of such may not yet be out of place.

The pressures and velocities given in connection with the several models represented in the accompanying drawings are derived from the tabulated results of Messrs. Noble & Abel's experiments combined with the data afforded in the test of the 10-inch wire gun at Sandy Hook in October last. The three rounds with 80 pounds of Du Pont's hexagonal powder "I. O. B. No. 2," in which we have the density of loading, are taken as coming more nearly to the conditions of service with

the new guns than anything else accessible, although the density of loading was very high, being 0.95.

The pressures were estimated upon the hypothesis that the observed pressure in the instance mentioned bears the same proportion to pressures exerted by the same quality of powder where the density of loading is different that the pressures of the products of complete combustion bear to each other with the same difference of densities. The hypothesis is not considered to be strictly correct, but is perhaps as nearly so as any that our present data will enable us to construct.

It was thought proper to take as a basis for the estimates a pressure somewhat higher than the highest recorded in the three rounds mentioned, as it is presumable that, had the firing been extended, higher pressures would have been indicated in the course of the ordinary variations in that respect, and the higher rather than the average pressures seem to be most important in this connection.

The coefficient of energy was derived from a comparison of the energy due to the observed velocity in the three rounds selected, with the calculated energy derived from Messrs. Noble & Abel's work.

1st. *Cast iron strengthened with bands of cold hammered or cold-rolled steel.* (See drawing No. 1.)

The essential difference between the structure here proposed and the banded cast-iron guns which have been brought into use, consists in the employment of rings of steel which have been extended in diameter and changed in mechanical properties by cold-hammering or cold-rolling before being fitted to the gun.

By this treatment the elastic limit of strain is carried higher than by tempering, while the remaining extensibility is very much more considerable, and the bands may safely be applied under greater tension.

The rule for the tension of strengthening-bands is (supposing the tension to be equal in all parts of their circumferences), that when the tube to which the band is applied shall be enlarged by internal pressure to the limit of its extensibility without rupture, the band shall be extended to the limit of the elasticity of its material. That this rule is not of easy application, with our present knowledge of metals and their variable qualities, is readily admitted. But a band of this description, having much remaining extensibility after passing its elastic limit, will, under moderate overstrains, be able to assume a new and higher limit of elasticity, at the expense of its further extensibility, which may yet remain sufficient for the demand to be made upon it. It will therefore be prudent to approach more nearly the best ascertained limits of initial strain in the application of the band than in the use of those which do not combine, in so great a degree, resistance and extensibility.

In a series of tests recently made at the Washington navy-yard, at my suggestion and under my supervision, the following results were obtained in the treatment of a specimen of steel in a manner analogous to that proposed for the bands. The steel employed had, when thoroughly annealed, an elastic limit of strain equal to 40,774 pounds per square inch, and a tensile strength of 71,530 pounds, with an extensibility, in a length of 2 inches and diameter of 0.5 inch, of 30 per cent. After cold-hammering, under blows acting upon only one pair of surfaces, its elastic limit of strain became 78,940 pounds, its tensile strength 86,580 pounds, with an extension of 14 per cent.

The best mode of applying such bands is undoubtedly by forcing them to their places by pressure acting at right angles to their planes. The preference for this method over that of shrinking on, after the ap-

plication of heat, arises from the more uniform distribution of strain in the different parts of their circumferences. From causes which need not here be particularized, the uniform cooling of a band contracting upon a mass of cold metal, is at least a matter of difficulty and uncertainty; and the part last to cool is subjected to the greatest strain, because the great friction of the band resists the equalization which would occur in its absence. In the mode first mentioned no such disturbing cause arises; and were the strains from any cause to be unequally distributed, the process itself would tend to restore uniformity, upon the principle that the tendency of every movement is in the direction of the resultant of the impelling forces. The contractility of the band, if not uniformly strained, would lend its assistance in bringing points in its circumference too widely separated under excess of local strain to their proper distances.

But the application of bands by the preferred method requires special and somewhat costly apparatus, which fact, together perhaps with a misapprehension of the advantages of the method, has led to the general adoption of "shrinking on" in its place. The great advantage of extensibility beyond a high elastic limit, to meet the uncertainties of the process, is evident.

The choice between the two suggested modes of preparing the bands, cold-hammering and cold-rolling, may perhaps be decided in favor of rolling, if questions of present convenience are left out of consideration, but it would be necessary to construct a plant to carry it into effect, and at very considerable cost.

There are several hammers in the country which could do the work well, with an inconsiderable outlay for special appliances.

The bands should be hammered on a heavy mandrel passed through them and supported on each side. Each blow should cover the width of the band operated on, and the blows should succeed each other at short intervals of space while the ring is carried round under the hammer.

The efficiency of the support rendered by bands applied to guns depends wholly upon circumstances not apparent upon mere inspection, and it is not surprising that differences of opinion, derived from ordinary observation, have prevailed upon the subject.

The amount of support afforded by a band is proportionate to its contractile force at the moment of the highest strain upon the gun, irrespective of its diameter.*

It may be worth while to see how much this force will amount to in several different cases. Let us first suppose the band to be of the same material and the same in all its qualities as the tube to which it is closely fitted, but without tension. It would be expanded by pressure within the tube precisely as if it formed a part of it. Nothing would be gained or lost as respects resistance by its being a separate piece of metal. But (varying the case) if the metal of the band possessed twice the elastic resistance to extension that was first supposed, its contractile force under the same extension and its support to the tube would be doubled. On the other hand, if its elastic resistance were but half as great, its support would be but half as much. So, too (varying the case again), if a band of the material first supposed were capable of twice the elastic extension it would receive under strain in the first instance proposed, it would, *if applied with proper initial tension*, give twice the

* This assertion is not at all in conflict with Professor Barlow's theory as announced by himself or as modified by the refinements of others. The only reason why the exterior portions of a homogeneous hollow cylinder give so little resistance to interior pressure is that they are so little brought into tension.

support to be derived from homogeneous metal. If the metal of a band had just twice the elastic resistance of the first with the same extensibility, and (like steel of high temper) its limit of elasticity and of extensibility were the same, its greatest efficiency would be secured when applied without initial tension.

Such a ring applied with tension, even though its tension were kept well within the limits of its strength, would render support varying from nearly its best to nothing at all, according to the degree of its tension when applied. It is to be borne in mind that the tube is compressed by the action of a band encircling it under tension, and rendered incapable of taking any part in resisting internal pressure until the force transmitted to the band has brought it relief by expanding the latter until its interior diameter is equal to that of the tube in its normal unstrained condition. Both the tube and the band must arrive at their limits of resistance at the same time in order that their combined resistances may be the sum of the capabilities of both. In the case last supposed the capability of the band is necessarily exhausted sooner than that of the tube, because it comes to rupture before the tube has reached its full expansion. If the band is applied with a tension very near its point of rupture a slight addition to the elastic expansive force of the tube (which equals, of course, the contractile force of the band) by internal pressure, will extend it to rupture, and that long before the tube has been able to offer *any* resistance. The band begins to afford assistance only when the initial strain is lowered to the point which permits the tube to return to its original diameter before the rupture of the band.

The examples proposed will, it is thought, be suggestive of the importance of the combination of high elastic resistance with a reserve of extensibility in a material for banding guns, enabling it to adjust itself in a considerable degree without injury to strains that would otherwise be fatal.

For the principal particulars respecting the banded cast-iron gun reference is made to the accompanying table and drawing No. 1.

In assigning so nearly one caliber (8¾ inches) as the thickness of the cast-iron walls, not only resistance to longitudinal strains has been considered, but also the effect of banding under heavy tension upon the metal. The effect of exterior compression by strains acting circumferentially is not only to reduce the diameter of a tube, but also to extend its length, in a way in some degree analogous to the drawing of ordinary brass and copper tubing. Cast iron is not in any considerable degree a ductile metal, and should not be required to submit to much change of form. Further, at the conjunction of the banded with the uncompressed portions of the tube, strains occur which impair its resistance to longitudinal stress. But for the considerations mentioned, the thickness of the walls might be very much reduced.

The body of the gun is slightly tapered, enlarging from the rear, in that portion which receives the bands. An average thickness of somewhat less than 3 inches and width of 9 inches has been assigned to them. They are applied in but two layers.

Reference has been had to simplicity of structure, and the limits of dimensions for steel rings of the desired character within the range of convenient and successful manufacture.

The Chambers, or, as it is more commonly called, the French system of *fermeture*, has been adopted as the best now known. The accompanying drawing (Plate IX) represents the system as adapted to the 9-inch converted rifle by the United States Navy.

To the screw are given a somewhat greater diameter and length than would be requisite in steel, in concession to the qualities of cast iron.

No interior tube of steel is proposed for the gun, not because it is supposed that it would not be thereby improved, but because it is considered that the system, in the presence of superior ones where high qualities are requisite, should be confined to a simple and not too expensive development.

The trunnions are placed at the position of the center of gravity when the breech-screw is removed.

The same adjustment is adopted with respect to all the guns proposed.

2d. *Cast iron strengthened with wire of high tensile strength, wound under tension and united with a solder of low fusibility.* (See drawing No. 2.)

The form and dimensions of the gun proposed under this system are nearly those given to the banded cast iron gun, the principal difference being that the chamber is one inch larger in diameter, and lengthened enough to receive a charge of 100 pounds of powder with a density of loading of about 0.8. The diameter of the cast-iron body of the gun is retained, and it is parallel where it receives the wire. Although the pressure of the wound wire will perhaps be greater than that of the bands, it is believed that it will be distributed with greater uniformity, and that for that reason the cast-iron portion of the gun will not be more severely taxed.

It is proposed to use hard-drawn wire 0.15 inch square (or a little larger), tinned before being wound. The wire may have a tensile strength of at least 150,000 pounds per square inch, and may be wound under a tension of 50,000 pounds or more to the same area, the tension being regulated by a self-adjusting apparatus.

For soldering, a temperature of only about 400° F. is required. The operation would be conveniently accomplished by the use of a bath of solder applied in an upright tank of boiler-iron just large enough to receive the gun, which, being temporarily closed at the breech, would be placed, muzzle upward, within it. The depth of the tank would need only to be sufficient to include the wound portion, which is wholly in the rear of the trunnions.

The band carrying the trunnions would be screwed and shrunken on after the soldering, its tension being moderate, and in consequence serving to ease the transition from the heavy strain of the wire upon the tube to the unconstrained condition of its forward portion. A lighter band forward of the trunnions will contribute to the same end.

3d. *A steel gun composed of a lining tube overlaid with longitudinal bars* (or "staves") *of cold-hammered steel and banded with cold-hammered rings of steel.* (See drawing No. 3.)

The lining tube may be of low steel, and thinner than usually employed. Its immediate envelope is a series of "staves" of cold-hammered or cold-rolled steel, which are intended to resist the longitudinal strain.

The best method of treating the metal of the "staves" at present available is, doubtless, by hammering in swages, cold, after annealing.

The results of this treatment in the tests made at the Washington navy-yard, before mentioned, upon the same steel as that used in the tests of which the results have been given, were as follows:

A specimen, the diameter of which was reduced by swaging from 2.05 to 1.62 inches, had an elastic limit of 85,000 pounds per square inch, with a tensile strength of 95,049 pounds and an elongation of 9.85 per cent.

Another specimen, reduced in the same way from 2.05 inches diameter to a diameter of 1.52 inches, had an elastic limit of 101,800 pounds per square inch and a tensile strength of 111,790 pounds, with an elongation of 8 per cent.

The aggregate area of the cross-section of the "staves" exceeds that of the chamber by 50 per cent. Their length is about half that of the finished gun. Near their forward end and covering the position of the shot when the density of the products of powder combustion has become 0.5, is attached by screwing and shrinking a band which receives the strain in recoil and communicates it to the trunnions by means of a tube or jacket or series of bands interposed between them. This arrangement is considered preferable to a direct attachment to the cylinder of "staves" at the position of the trunnions, as permitting a better provision for the greater strain upon the gun at that place.

The bands which furnish the resistance to tangential strains are put on in three layers as far forward as the trunnion-band; thence, for a distance of some feet, in two, and forward of that to the muzzle in a single layer. The width and thickness of the bands are such as to come within the requirements imposed by the means of producing them of the proper quality.

The considerable number employed may be supposed to distribute the strain of their contractile tendency more justly than would a small number of heavy bands. They *ought to be* forced to their places by hydraulic or other direct pressure.

The tension with which they are applied should in each layer be near the elastic limit, for the material has sufficient extensibility beyond that point to make it quite safe to allow it to make its own adjustment.

4th. *A steel gun having a lining tube of steel overlaid with longitudinal bars of cold-hammered steel, and wound with steel wire applied under high tension, subsequently united with solder of low fusibility.* (See drawing No. 4.)

The portions of the gun intended to meet longitudinal strains closely resemble the corresponding parts of the one last described.

Wire is substituted for the bands in a manner that will be apparent upon inspection of the drawing. Two or three wires may be wound at a time as a matter of economy. For soldering, the gun may be inclosed in a close-fitting case, resembling a boiler, and the operation conducted with the gun in a horizontal position. The union of the soldering metal affords a detrusive resistance of about 3,000 pounds per square inch of soldered surface (2,972 pounds in a recent experiment). A wire of the size proposed to be used (0.15 inch square) would be attached strongly enough, if soldered on all sides for a length of 2 inches, to withstand a strain of more than 150,000 pounds per square inch on the wire. It is unnecessary to provide any protection to the wound wires when thus united, and they may be turned with a light cut over the exterior, to give a finish.

The wire should have a high elastic limit of strain with a safe extensibility beyond that limit.

It is evident that in winding, the interior layers, if applied with the same tension as those succeeding them, will, as the process goes on, become more and more relieved of tensile strain (in consequence of the compression of the interior portions and reduction of their diameters) until, if the process is carried far enough, they will be wholly freed from it. A still further continuance of the process would, of course, effect compression in the direction of the length of the wires. This, it is presumed, would rarely occur in practice. But to whatever extent the ef-

fect mentioned may be produced, when the gun is subjected to internal pressures the exterior wires will *first* be brought to a tension greater than that with which they were wound. Inasmuch, however, as the rate of extension in the different layers is nearly in inverse proportion to the squares of their distances from their centers, the interior layers soon reach an extension by which their tension is brought to overtake or surpass that of the exterior.

In order, then, that the whole mass of wire should do its utmost in resistance, within the limit of its elasticity, the uniform strain on the wire in winding should be such that when the innermost layer has expanded so far as to bring the tension upon it to its elastic limit, the exterior layer will have reached the same limit also.

If the wire be wound under a tension equal to its limit of elasticity, and afterwards subjected to an internal strain which will restore the innermost layer to that tension, each layer outside of it will have been extended beyond its *original* elastic limit, and have assumed a new one slightly higher. This may occur without any disadvantage if the extensibility of the wire is what may easily be given to it, in combination with a high elastic limit, reaching without doubt as far as 100,000 pounds per square inch.

The drawing of this gun represents the tube as being composed of two pieces, *not because two are preferred to one*, but to illustrate the fact that the system admits of the use of a divided tube if necessary.

5th. *A gun composed of a steel tube wrapped with steel wire and brazed* (See drawing No. 5.)

This system has been fully described in previous communications to the Ordnance Department.

Its principal features may be given in a few words.

The material of which the gun is principally composed is steel wire, drawn square, with the corners slightly truncated.

This is wound upon a steel tube, in successive layers. A sufficient number of wires are wound at once to form, when placed side by side, a band about equal in width to the diameter of the bore of the gun, which gives them the proper obliquity. The tube is closely covered in this way, from end to end, and with layer after layer, until the mass has reached the full size of the gun.

The whole is then inclosed in an air tight case of boiler-iron, and, thus protected from oxidation, is heated to the melting-point of bronze, when liquid bronze is supplied in such a way as to interpenetrate the mass and unite it, when cooled, into one solid piece, to be afterward turned and finished to the proper form and dimensions.

The advantages of a proper distribution of initial strains are procured by cooling from the interior, in the manner practiced by the late General Rodman, employing a current of air for that purpose.

The 10 inch gun lately fired at Sandy Hook was made in accordance with a resolution of the Board of Ordnance officers convened in September, 1873, "to recommend the place, manner, and details of the construction of the heavy guns selected by the Board instituted under the act of June 6, 1872," recommending—

That a preliminary gun of smaller caliber be made on Dr. Woodbridge's plans, for the purpose of giving the necessary experience to the workmen to construct the 12-inch gun determined upon.

The course of construction, proof, cutting up and tests of the material of the gun have furnished much of the instruction it was designed to afford.

The importance of a sufficient heat in the process of soldering has been emphasized, and the results of a deficiency made manifest in its various relations, while the sufficiency of the means of determining the heat, with proper adjustment, has also been shown.

This passing tribute may, it is believed, be paid to the gun, that "with all its imperfections on its head," no other gun in this country, since the days when such (fabulous) pressures as 240,000 pounds per square inch were occasionally read, *has* sustained (whatever might have been) nearly an equal number of rounds, giving pressures of equal severity.

It yet stands alone, also, so far as known to the writer, in showing contraction in the region of the greatest strain after firing full charges.

Accepting, without remark in this place, the conclusions which have been drawn from the Watertown tests, we have a detrusive resistance in the attachment of the tube to the surrounding wire of 19,418 pounds per square inch. This is sufficient in *ten inches* of the length of the tube to resist the thrust of a pressure of 100,000 pounds per square inch within the bore.

The average strength of the specimens tested for longitudinal resistance, as given (though about half that indicated in other experiments), is over 19,000 pounds per square inch. This, neglecting the resistance due to the oblique winding of the wires, and leaving out the aid of the tube, gives a resistance, calculated on the area of the cross section of the gun, more than equal to the strain produced by an internal pressure of 200,000 pounds per square inch.

I have also thought best to submit a drawing (No. 6) presenting the manner in which the steel tube now at Frankford Arsenal could be used in the construction of a 10-inch gun. To procure a length of 25 calibers, it would be necessary to add a piece to the tube, as represented in the drawing. It can hardly be considered a satisfactory model for a gun of high power—the diameter of the tube restricting within too narrow limits the diameter of the chamber. If the question of endurance of strains merely were the object of construction, it might well meet that demand.

6th. *A brazed steel-wire gun on the system last mentioned, with the addition of reinforce of a hard-drawn steel wire wound over the chamber.*

The accompanying drawing (No. 7) and the sentence above will sufficiently indicate the proposed construction. It is based upon the idea that after providing in the foundation structure for the longitudinal strength required in common with the tangential resistance, the latter may be further increased by the addition of a material of still higher strength as related to that kind of resistance.

Though the pressure of gunpowder has its limits, it can hardly be doubted that in very large charges, such for instance as that proposed for the gun represented, 1,250 pounds, the local or wave pressures produced by the surging of the large mass of gasses and fluid material generated must be more violent than in smaller guns and call for greater strength to control them.

This structure is proposed for guns of very large caliber.

COMPARISON OF SYSTEMS OF CONSTRUCTION.

In examining briefly the relative merits of the modes of construction here proposed, we may begin with the strengthened cast-iron guns.

Comparing either of them with guns of cast iron only, we find a resistance, in addition to that of the cast-iron body, equal to the whole contractile effort of the added bands or wire, exerted at the time when the gun has reached its limit of expansion, and which, upon any just

principles of estimation, will be found to have rendered the combined resistance considerably more than double that of the unaided cast iron, even under the supposition that the cast iron is of the best quality, and that the effect of interior cooling has been to produce the best possible arrangement of initial strains.

That but a small part of this added strength would be gained by increasing the diameter of the cast-iron gun to that of the bands or winding, will hardly be questioned.

In comparison with other banded guns (when the bands have been judiciously applied) the claim for superiority must rest on the superior merit of the material used for bands.

As the added strength in either case depends upon the contractile force of the bands or wrapped wire at the moment when the body shall have reached its limit of extension, a comparison of elastic limits of strength and extension, and, as an element in the availability of the qualities mentioned, of extensibility beyond the elastic limit, must decide.

Comparing the two systems of strengthened cast iron between themselves, the wound gun, it is believed, must have the preference, both in strength and facility of construction. The material may be even superior, and the mode of application will secure the most uniform possible distribution of pressure upon the surface of the body of the gun. This makes safe the application of greater compressive force, and consequently of higher tension and greater resistance in the envelop, permitting increased charges and the greater efficiency of the piece.

In considering the position on the scale of merit of the steel-tubed guns in which longitudinal cold-swaged bars or "staves" are used as the principal reliance for longitudinal strength, while bands or wires furnish the tangential resistance, it may be well first to compare them between themselves.

In a general way, the question between bands and wire must be decided as in the former case. But in that portion of the gun which is forward of the band from which connection between the "staves" and the trunnion-band is made, the bands may, especially in naval use, where it is expected that guns will be fought behind armor, but with their chases always protruding (and exposed in a greater degree than in land service to being struck with missiles of moderate but injurious size), have the advantage of being less liable to injury than wires soldered as proposed. Of course the systems may be combined in the way which suggests itself from what has just been said—the portions receiving the greatest strain being wire-wound, and the chase being banded, without any want of harmony.

Taking, then, the wire-wound gun as the better representative of the two allied systems we are considering, we may compare it, first, with the strengthened cast-iron guns lately mentioned. The relatively deficient strength of the cast-iron guns must be apparent. The body or tube upon which the bands are shrunken or wires are wound is not of a material which will bear without injury the constricting (or compressing) force which may be applied upon a steel interior, and upon that force tangential resistance principally depends. As relates to *cost*, if the question be considered simply as to price per pound, or even as to guns of the same caliber, the cast-iron gun may have the preference. But this is not the rule of comparison. If a certain standard of energy within the capacity of the cast-iron guns be fixed (and other qualities, such as mobility, economic use of powder, &c., be neglected), we come nearer a basis for an estimate of relative values, and one which may in some cases be justly employed; but when the duty of a gun is placed beyond the point that the cast-iron guns can attain, there is no common

ground upon which a comparison can be constructed. That which cannot do what must be done, becomes valueless.

We turn now to the various "built-up" guns so well known in European practice. It is by no means intended to ignore the excellent work that has been accomplished. But the recent pushing toward the use of wire (to speak of nothing else) seems a confession of much yet to be desired. As structures of this class seem now to be in advance, we may confine our comparison to them. In these guns there are two "organs" (as they have been properly called) for resisting the expansive force of the fired gunpowder, one for controlling the longitudinal effort, and the other resisting the lateral or tangential strain.

The same dual arrangement is found in the gun proposed. The interior tube takes some part in the resistance to both the strains mentioned, but the longitudinal effort of resistance is committed chiefly to the series of bars forming a tube of staves immediately surrounding the lining tube. By the treatment to which they are subjected, they acquire a resistance within the elastic limit of strain which is quite unknown in tubes of one piece. Each component bar or stave is susceptible of a reliable test before it enters into the structure, so that its size and the proper amount of work to be committed to it may be well determined. We have also in these swaged staves a resistance to the constricting or crushing force of the wound wire far greater than steel in an ordinary gun-tube is capable of offering. A tension that would greatly reduce the diameter of the latter, with longitudinal extension, would be borne by the staves without permanent change of condition.

As relates to the means of tangential resistance, the important feature consists in the union of the wires by a solder of low fusibility. The temperature at which this soldering is done does not impair in the least their elasticity or strength. As a means of perfect fastening alone it seems complete. A very few inches of soldering attach the wire with a strength equal to its tenacity without any impairment of that quality to fit it for bending or other change of form. Soldering also fixes it unchangeably in the position assigned to it in winding, avoiding the creeping tendency which must result from the irregularity of the strains brought upon the same continuous wires in the same layers in different parts of their lengths. The perfect filling of the spaces between wires in different layers (which, without soldering, are in contact only upon very small surfaces) must contribute to the permanent maintenance of the original strains, which would otherwise be in some degree lessened by the compression of the wire under the action of firing at the small surfaces of contact.

The soldering of the wires makes it ordinarily unnecessary to resort to exterior bands for its protection. The solder itself excludes water and atmospheric influences. The cutting of a wire or two in *unsoldered* masses releases the whole of the continuous wire, while the injury which should divide a number of the *soldered* wires would be only local.

The gun of brazed steel wire presents greater simplicity of construction than either of the structures previously mentioned. A lining-tube and a covering of brazed wire constitutes the whole. It may be treated as being completely a unit, and its dimensions may everywhere be made to conform to the interior strains (if known), so that no superfluous metal shall remain, and the vent may be inserted at the most advantageous point. By the process of interior cooling the whole mass of wire may be brought into high tension quite within the limit of its extensibility.

The brazed-wire gun needs no duplication of "organs" to enable it to meet the longitudinal strain. This is asserted of a well-brazed gun; the

qualifying words being suggested, and perhaps demanded, by the recent longitudinal parting of the 10-inch wire gun at Sandy Hook. The occurrence mentioned demonstrates that with the obliquity of winding employed in that gun, and with the imperfection (very great it must be called) existing in the brazing at the location of the separation, the longitudinal strength was insufficient to meet the heavy strains to which it was exposed. It seems also to be demonstrated that with quite imperfect brazing the longitudinal strength was sufficient to resist the high pressure of 74,400 pounds to the square inch, in that part of the gun, too, in which the longitudinal strain is necessarily the greatest—that is, in the plane of the bottom of the bore.

It is now perfectly evident, too, that the cause of imperfect brazing was the want of a sufficiently high temperature in the lower portion of the mass of wire.

The application of the remedy is simple and has already been stated.

The fact that a gun was not perfectly brazed when insufficiently heated, affords not the least presumption against its being perfectly brazed when sufficiently heated.

The endurance of longitudinal strain by the small wire gun tested at Springfield Armory in 1865 perhaps deserves mention here. Though the internal pressures were not taken, a valuable comparison may be deduced from the results. Of the 1,327 rounds there fired, 537 were with projectiles of 10.22 pounds weight each, the charge being one pound of small-grained powder. Taking the area of the section of the bore, including the grooves, to be 5.1 square inches, the mass of metal opposing the action of the gases by its inertia would be, with sufficient accuracy, 2 pounds to each square inch. The corresponding relation in the 10-inch gun with a 400-pound projectile is almost exactly 5 pounds to each square inch. We will make the supposition, for the present purpose, that the pressure of the powder will be increased in proportion to the weight of the projectile compared with a given area of pressure. We will also assume one caliber as not an unreasonable thickness for the gun. In the Springfield gun we had but half a caliber, the area of section in that case being as 3 to 8 in the gun of one caliber thickness.

It results, then, that upon the assumption that the small gun was strained to its utmost resistance (which is more than we have any reason to suppose), and that the pressures in the 10-inch gun were two-and-a-half times those in the smaller gun (a supposition probably erring on the side of excess), we still find the strength of the brazed gun in excess of the demand.

The brazed-wire gun has manifested a tangential resistance by contraction of the bore in the powder chamber and resistance to enlargement under heavy pressures without a parallel, so far as known.

Comparing the brazed-wire system with that in which the wires are united with a solder of low fusibility, in respect of strength, no very decided superiority appears on either side.

The greater tangential resistance for an equal area of section is decidedly with hard-drawn wire; and if *static* resistance only is to be considered, the system in which it is employed must probably be given the preference in respect to ultimate capability. The necessity of employing two elements or "organs" of resistance in the structure of a gun—meeting the longitudinal and tangential resistances separately—must, however, be considered undesirable.* Either system seems to be capable of giving all the resistance required in dealing with gunpowder.

*The supposition maintained by some that the two kinds of resistance exerted by a hollow cylinder—tangential and longitudinal—are antagonistic to each other, and

In respect to cost and the time required for the fabrication of guns, after the establishment of the manufacture, the brazed-wire system must have the preference, though on the other hand the plant required for the gun united with solder of low fusibility would be less expensive.

The union of the brazed-wire system with the winding of hard-drawn wire, as illustrated in drawing No. 7, is believed to carry resistance to the action of internal explosive forces as far as is possible in the present state of the arts.

PROJECTILES. (See drawing No. 8.)

The principal peculiarity of the projectiles proposed for rifled guns consists in the treatment to which the material is subjected. For use in guns of high power, no other material than steel is considered to be really suitable, especially for use against armor.

It is important that projectiles for that purpose should have great resistance to deformation upon impact, for the reason that the work done in changing the form and molecular condition of the material on striking, is, at best, so much deducted from the energy of the projectile, while the projectile itself is often so changed as to become unfitted for the service intended.

The kind of steel considered most suitable is one which, with normal constitution, would have a tensile strength, when annealed, of 100,000 pounds or a little more. It should first be forged hot, as usual, and then annealed, after which it should be "upset" cold, by hammering or pressure.

Both solid projectiles and shells may be subjected to this process with advantage. The rigidity of steel is so much increased by this treatment that hollow projectiles may safely be made much thinner, and therefore capable of receiving larger bursting charges; or, if shrapnel, a larger number of balls.

The means of giving rotation consist in the application to the projectile of an expanding sabot, represented in section in the accompanying drawing. Its action will be readily understood from inspection. It is forced by the pressure of the gases developed from the charge of the gun into the grooves and against the rear surface of the projectile, maintaining its hold upon each by precisely similar action. The enlargement of the ring at its rear serves to determine the position of the projectile in the gun, and to give, in the first moment of pressure, a gas-tight contact with the walls of the chamber at its junction with the rifled bore, which contact the valvular action of the sabot tends to maintain. Upon

that there is therefore an advantage in employing separate portions of a gun to meet them independently, cannot be considered to be well founded.

In the series of experiments already mentioned as having been recently made at my suggestion at the Washington navy-yard, is the following:

Two hollow cylinders from the same steel, thoroughly annealed at the same time, and in all respects receiving, in every stage of their production, identical treatment, were submitted to longitudinal strain, one being empty and the other subjected to an interior strain of known relation to the tensile stress.

Each was 1″.000 in diameter exteriorly, and was bored to an interior diameter of 0″.750, giving a cross-section of 0.3436 square inch. The measuring-points for longitudinal extension were 5″.000 apart.

The specimen without interior pressure was permanently elongated by a strain of 12,000 pounds to the extent of 0″.050. The specimen with interior pressure was permanently elongated 0″.051 by a strain of 13,200 pounds.

With a strain of 15,000 pounds the specimen without interior pressure was permanently elongated 0″.106, while the specimen with interior pressure was elongated but 0″.086 by a strain of 15,600 pounds.

The specimen without interior pressure broke with a strain of 23,505 pounds. The specimen with interior pressure (which at the time of breaking, amounted to 9,458 pounds per square inch), bore, before breaking, a strain of 25,091 pounds.

the perfection of this action freedom from "scoring" or "channeling" of the bore, of course, depends.

The similarity between this sabot and some others now in use and known by other names, makes it proper, the writer believes, that he should justify his claim to the invention by reference to facts to be found in the records of the Ordnance Department.

Reference is especially made to the record of firing with his rifled gun at Fort Monroe in the autumn of 1850. The library of the department contains a copy of his pamphlet relating to projectiles with expanding sabots, printed in 1852, and which has been in the possession of the department since that time.

The accompanying plate (No. X) is a photolithograph of a tracing of one of the plates in the pamphlet referred to, furnished to the writer by the department at his request.

SUMMARY OF THE PRINCIPAL DIMENSIONS, CHARGES, CALCULATED ENERGIES, &C., OF THE PROPOSED GUNS.

10-inch cast-iron gun, banded, 25 calibers; bands cold-hammered. (Plate I.)

Caliber	inches..	10
Weight of projectile	pounds..	400
Weight of powder charge	do....	80
Length of bore	calibers..	25
	=inches..	250
Length of gun	inches..	270
Greatest diameter	do....	40
Weight of gun	pounds..	52,000
Maximum diameter of powder chamber	inches..	10.5
Length of powder chamber	do..	36
Capacity of chamber	cubic inches..	2,960
Density of loading		0.75
Maximum powder pressure (estimated)	pounds..	30,552
Muzzle velocity	feet per second..	1,520
Muzzle energy	foot-pounds..	14,850,310
Muzzle energy	foot-tons..	6,460.39
Penetration in iron (by Colonel Maitland's formula)	inches..	17.23
Estimated cost		$12,000
Outlay for special tools		$500

10-inch cast-iron gun, wire wound, 25 calibers; wire soldered. (Plate II.)

Caliber	inches..	10
Weight of projectile	pounds..	400
Weight of powder charge	do....	100
Length of bore	calibers..	25
	=inches..	250
Length of gun	inches..	270
Greatest diameter	do..	40
Weight of gun	pounds..	52,000
Maximum diameter of powder chamber	inches..	11.5
Length of powder chamber	do....	40
Capacity of chamber	cubic inches..	3,465
Density of loading		0.8
Maximum powder pressure (estimated)	pounds..	34,578
Muzzle velocity	feet per second..	1,652
Muzzle energy	foot-pounds..	16,959,626
Muzzle energy	foot-tons..	7,571.26
Penetration in iron (by Colonel Maitland's formula)	inches..	20.36
Estimated cost		$8,500
Outlay for special tools		$750

12-inch steel gun, longitudinal bars, banded, 30 calibers; bars and bands cold-hammered. (Plate III.)

Caliber	inches..	12
Weight of projectile	pounds..	800
Weight of powder charge	do....	400

Length of bore	calibers..	30
	=inches..	360
Length of gun	inches..	388
Greatest diameter	do....	44
Weight of gun	pounds..	107,000
Maximum diameter of powder chamber	inches..	14.6
Length of powder chamber	do....	86
Capacity of chamber	cubic inches..	13,200
Density of loading		0.80
Maximum powder pressure (estimated)	pounds..	39,105
Muzzle velocity	feet per second..	2,075
Muzzle energy	foot-pounds..	53,406,909
Muzzle energy	foot-tons..	23,842.37
Penetration in iron (by Colonel Maitland's formula)	inches..	44.54
Estimated cost		$45,000
Special tools or "plant"		$2,000

12-inch steel gun, longitudinal bars, wire wound, 30 calibers; wire soldered. (Plate IV.

Caliber	inches..	12
Weight of projectile	pounds..	800
Weight of powder charge	do....	400
Length of bore	calibers..	30
	=inches..	360
Length of gun	inches..	384
Greatest diameter	do....	48
Weight of gun	pounds..	108,000
Maximum diameter of powder chamber	inches..	14.6
Length of powder chamber	do....	80
Capacity of chamber	cubic inches..	13,200
Density of loading		0.85
Maximum powder pressure (estimated)	pounds..	39,105
Muzzle velocity	feet per second..	2,073
Muzzle energy	foot-pounds..	53,406,909
Muzzle energy	foot-tons..	23,842.37
Penetration in iron (by Colonel Maitland's formula)	inches..	44.54
Estimated cost		$33,000
Special "plant"		$3,000

12-inch brazed steel-wire gun, 30 calibers. (Plate V.)

Caliber	inches..	12
Weight of projectile	pounds.	800
Weight of powder charge	do....	400
Length of bore	calibers..	30
	=inches..	360
Length of gun	inches..	384
Greatest diameter	do....	48
Weight of gun	pounds..	105,000
Maximum diameter of powder chamber	inches..	14.6
Length of powder chamber	do....	80
Capacity of chamber	cubic inches..	13,200
Density of loading		0.85
Maximum powder pressure (estimated)	pounds..	39,105
Muzzle velocity	feet per second..	2,073
Muzzle energy	foot-pounds..	53,406,906
Muzzle energy	foot-tons..	23,842.37
Penetration in iron (by Colonel Maitland's formula)	inches..	44.54
Estimated cost		$37,500
Addition to "plant"		7,000

Proposed 10-inch brazed gun, with Frankford Arsenal tube. (Plate VI.)

Caliber	inches..	10
Weight of projectile	pounds..	400
Weight of powder charge	do....	150
Length of bore	calibers..	25
	=inches..	250
Length of gun	inches..	270
Greatest diameter	do....	40

Weight of gun	pounds..	48,500
Maximum diameter of powder chamber	inches..	11.1
Length of powder chamber	do....	52
Capacity of chamber	cubic inches..	4,891.6
Density of loading		0.85
Maximum powder pressure (estimated)	pounds..	39,105
Muzzle velocity	feet per second..	1,907
Muzzle energy	foot-pounds..	22,582,110
Muzzle energy	foot-tons..	10,082.29
Penetration in iron (by Colonel Maitland's formula)	inches..	27.12
Estimated cost (using tube at Frankford Arsenal)		$16,500
Estimated cost, employing longitudinal bars		$18,500
Alteration of plant		$1,500
Estimated cost of 10-inch 30-caliber gun for charge equal to one-half the weight of the projectile		$20,500
Alteration to "plant"		$5,000

18-inch brazed steel-wire gun, reinforced wire, soldered. (Plate VII.)

Caliber	inches..	18
Weight of projectile	pounds..	2,500
Weight of powder charge	do....	1,250
Length of bore	calibers..	30
	=inches..	540
Length of gun	inches..	576
Greatest diameter	do....	78
Weight of gun	pounds..	384,000
Maximum diameter of powder chamber	inches..	21.9
Length of powder chamber	do....	120
Capacity of chamber	cubic inches..	44,550
Density of loading		0.85
Maximum powder pressure (estimated)	pounds..	39,105+?
Muzzle velocity	feet per second..	2,073
Muzzle energy	foot-pounds..	166,896,598
Muzzle energy	foot-tons..	74,507.41
Penetration in iron (by Colonel Maitland's formula)	inches..	61.86
Estimated cost		$120,000
Addition to "plant"		$75,000

RECOMMENDATIONS OF THE BOARD ON HEAVY ORDNANCE AND PROJECTILES RESPECTING THE PLANS OF CONSTRUCTION PRESENTED BY W. E. WOODBRIDGE.

Dr. W. E. Woodbridge's plan of a wire wound cast-iron gun, wire soldered (Plate II), and Plans M and H, submitted by the Chief of Ordnance:

The Board is of the opinion that the combined cast-iron and steel guns represented in the plans submitted by the Chief of Ordnance with his letters of January 17 and April 29, 1882, marked M and H, and in the plan submitted by Dr. W. E. Woodbridge with his letter of March 29, 1882, modified by letter of May 3, 1882, and marked Plate II, should be constructed and tried, for the following reasons:

1st. Experience thus far gained with similar guns promises for the combination success within usual limits of powder pressure.

2d. They can be readily and rapidly produced in this country without incurring the delay of sending to foreign countries for large masses of forged steel. The great weight of the foregoing guns recommended for test is, however, objectionable, and this Board would prefer such combinations of materials possessing the highest tensile strength as will produce, with less weight, a gun capable of giving the high velocities now sought for. But while this latter class of guns is being developed through a series of careful and costly experiments, some cheaper gun, though of less power, susceptible of rapid production, in case of need, should be determined upon, so that the country may not be left entirely defenseless.

The estimated cost of the construction and test of these guns is:

For construction:	
Of gun represented by Plate II	$11,100 00
Of gun represented by Plan M	37,289 00
Of gun represented by Plan H, including $6,000 for preparation	41,170 00
Total	89,559 00
For test:	
Of gun represented by Plate II:	
Powder, per round	$25 50
Projectile	39 00
Labor, &c., during test, per round	13 10
Total, per round	77 60
Of gun represented by plan M:	
Powder, per round	$76 00
Projectile	72 25
Labor, &c., during test, per round	15 75
Total, per round	164 00
Of gun represented by Plan H:	
Powder, per round	$70 89
Projectile	72 25
Labor, &c., during test, per round	15 75
Total, per round	159 89

Dr. W. E. Woodbridge's brazed steel-wire gun, Plate VI:

A gun of 10-inch caliber, after the design of Dr. W. E. Woodbridge, was recommended for construction by the Board on Heavy Rifled Ordnance, convened by General Orders No. 57, of June 28, 1872. This device involved a steel tube to be bound around by steel wire under the requisite tension, and to be united by brazing with bronze. The gun was constructed at Frankford Arsenal and submitted to a trial of 93 rounds, 83 of which were fired under the direction of this Board. It burst into two parts, just behind the trunnions, under a powder pressure of about 80,000 pounds to the square inch, as measured by the Rodman gauge. An examination and tests, at the Watertown Arsenal, of sections cut from the broken gun revealed the fact that the brazing was imperfect. Several difficulties occurred in the construction of this piece from the lack of experience in applying the brazing system to so large a mass; and, further, it seems probable that undue initial strains were developed on the exterior in cooling which assisted largely in producing the transverse rupture. Could the brazing have been moderately well effected, and the interior and exterior coolings properly regulated, it is believed that the gun would have been exceptionally strong. It is a merit of this method of construction that the material is not liable to give way, causing rupture, without previous indications. The transverse crack behind the trunnions, where the rupture took place, increased during the firing by increments so minute that, from the 65th to the 85th round, that increase amounted to only $\frac{1}{100}$ of an inch. There could, therefore, be little if any apprehension that guns made after Dr. Woodbridge's system would burst without previous warning, though imperfectly constructed.

In view of the fact that the gun tried stood quite severe tests, notwithstanding its imperfections, and that the plant used in its construction still exists at Frankford Arsenal, it is recommended that another 10-inch gun, after the model presented by Dr. Woodbridge (Plate VI, accompanying his letter of March 29, 1882), be made for further trial. It is suggested that the method of strengthening the walls of the gun as against longitudinal strains, shown on his drawing for a 12-inch gun (Plate IV), be adopted in the construction proposed.

Not unanimous.

The estimated cost of the construction and test of this gun is—

For *construction*, including alteration to "plant"	$25,500 00
For *test:*	
Powder, per round	$51 00
Projectile	39 00
Labor, &c., during test, per round	13 10
Total, *per round*	103 10

Dr. W. E. Woodbridge's steel gun, longitudinal bars, wire-wound wire-soldered (Plate IV):

It is the opinion of the Board that the plan of a 12-inch gun submitted by Dr. W. E. Woodbridge, Plate IV, accompanying his letter of March 29, 1882, consisting of steel tubes and bars strengthened by wire wrapped and soldered, presents a combination and arrangement of material and parts which gives sufficient promise of strength to warrant a trial of this system of construction. The large charge of powder and heavy shot proposed to be used places it in the front rank of high-power guns, and while there may be some doubt as to its ability to endure what is claimed for it, especially with the present arrangement of the two tubes, it is believed that a high-power gun can be made on this general plan, and it is with this view that the Board recommends that a 10-inch gun on this plan be made and submitted to actual test.

(For action, see page 74, proceedings of the Board.)

The estimated cost of the construction and test of this gun is—

For *construction*, including special "plant"	$25,000 00
For *test:*	
Powder, per round	$51 00
Projectile	39 00
Labor, &c., during test, per round	13 10
Total, *per round*	103 10

Dr. W. E. Woodbridge's plan for gun construction:

The plan of an 18-inch brazed steel-wire gun reinforced with wire soldered, submitted by W. E. Woodbridge, marked Plate VII, was laid aside, being of too large a caliber to warrant a recommendation for its actual test, since experiments to test the efficiency of the wire system are but just commenced with guns of 6-inch, 8-inch, and 10-inch calibers.

The following designs for guns are *not recommended* for actual test, as the Board has preferred others of the same class for that purpose:

Design for—	Submitted by—	For action, see page of proceedings No.—
Gun construction. Designs A, D, E, F, G, H, I, J, K, L, B_2, F_2, I_2, M, N, O, and P	William P. Hunt	70, 71, and 75
Wire-wrapped cast-iron rifle	Col. T. T. S. Laidley	70
Cast-iron gun banded and steel gun. Plates I, III, and V	Dr. W. E. Woodbridge	70, 71, and 74
Gun construction. Plates A_1, A_2, A_3, B_1, B_2, C_1, , C_2, E_1, E_2, F_1, F_2, G, and K, D_1, and D_2.	Chief of Ordnance	70
Gun construction. Plates 1, 2, 3, 4, and 5	A. H. Emery	71
Wire gun	Lt. C. C. Morrison	75
Steel gun, on Schultz's plan	Col. S. Crispin	75
Steel gun	L. W. Broadwell	37
Heavy ordnance	D. G. Smith	31

W. E. Woodbridge's rifle projectile:

The rifle projectile proposed by Dr. W. E. Woodbridge, shown in Plate VIII, accompanying his letter of March 29, 1882, is recommended as worthy of actual test in competition with other projectiles.

STATEMENT OF WM. WHEELER HUBBELL.

Mr. HUBBELL. Your inquiry is as to "heavy ordnance and projectiles." I wish to state a few principles involved in that matter so that we may be able to cover the whole ground.

When I commenced the invention of projectiles for heavy ordnance, which was in 1840 and 1842, the largest guns were eight-inch. They were called heavy. Captain Stockton undertook to make a twelve-inch smooth-bore gun. I invented the explosive shells for shell guns, which were then considered large. I made the invention of the shells and fuses with which the whole Navy of the United States has been armed since 1855, automatic explosive shells. The effect of these shells has been to revolutionize and bring about the necessity for the system which is now called "heavy ordnance." Of course "heavy" is a relative term. Heavy ordnance at the present day would necessarily involve the use, as I will explain, of both rifled guns and smooth-bore guns of larger size than those which were used at the time I mention, which were then eight-inch. "Heavy" now would be ten, twelve, or fifteen-inch guns.

The effect which my inventions gave to explosive shells drove foreign governments to the necessity of building iron-clads. The first experiments in relation to building iron-clads and the use of heavy guns were made at the time that I made my experiments at Sandy Hook, by Robert L. Stevens. I remember well that Mr. Stevens constructed a target there 3½ inches thick, I think it was, of several series of iron plates, and that showed that iron resisted what were then called heavy guns. Commodore Stockton came there with his 12-inch wrought-iron gun made in England and he drove a 12-inch shot through that target of Stevens's. He attempted to make a 12-inch wrought iron gun at the West Point foundry. They made it of pieces of metal welded together, and that experiment proved that it was impracticable to weld pieces of metal together so as to establish a uniform strength, and the gun in several trials burst on the Princeton, so that all idea of making heavy guns by welding pieces of metal together exploded with that explosion.

The first gun which Commodore Stockton made, however, had a barrel which was not quite thick enough; it was made in England, but so tough was the metal, and so well was it welded together, that although it did not burst, it began to crack at Sandy Hook, under these charges, firing at this wrought-iron target which Robert L. Stevens had built, and other experiments which Commodore Stockton conducted there. That was taken to the West Point foundry and banded; it had a band put upon it, and it was afterwards fired a little and laid aside as having reached its limit, and for many years it was in the Philadelphia navy-yard It was called the Oregon. That gun, as well as the other, proved, however, the impracticability of making these large guns of wrought metal welded together, and the object has been since that, and since England has commenced the construction of iron-clads, and also to construct heavy guns, to find out some way in which a gun either cast or otherwise can be put together without being welded in mass, and which will give sufficient strength to resist the strain that is necessary.

This conflict between the power of resistance and the power of guns has been going on from that time to this, and we have reached a point where it has been shown that the aggressive power of the gun is superior, that man cannot build a ship or a target so strong that will

float and be navigable on the ocean, but what a gun of some kind can be made that will penetrate that armor at some distance; the shorter the distance, the greater the penetration, of course, because the higher the velocity.

But the question comes in as to the endurance of the gun. These guns all diminish in strength as the firing continues. The vibrations seem to bring about a tendency of all metal to rupture. Another point is—which comes under the law of force and resistance and the destructive effect to be derived from projectiles—that the greater the volume or mass of a projectile, the greater will be its destructive power; the higher its velocity, the greater will be its destructive power; but in order to increase the velocity without diminishing the mass of the metal you have got to increase the power of the gun—that is, the strength of the gun together with its size. That, then, is what we are now properly aiming at in this matter. The theory that some persons have advanced of diminishing the mass of the projectile and increasing its velocity will never answer. You might as well try to fight a battle by shooting tallow candles, because you can shoot a tallow candle through an inch board. You may increase the velocity of a projectile by diminishing its weight, but just as you diminish its weight you diminish its destructive power. You may increase the penetration of a projectile by making it pointed without increasing its mass. Just as you increase that pointed shape you may increaseits penetrative power; but that does not materially increase its destructive power, because you do not increase its mass.

What we must understand, therefore, in this age of progress in science upon this subject, by "heavy ordnance and projectiles," must mean projectiles which have great mass, guns which have great strength, capable of carrying great charges and throwing a projectile with very high initial velocity. That is what we have to come to; otherwise we shall fail entirely in a contest with iron-clads so far as guns are concerned for penetrative power or effect of that kind.

There is another principle involved in this matter which I know about, and which some ordnance officers know about, and that is this: We have heretofore principally fought our battles with smooth-bore guns. In the last war, rifled guns and rifled projectiles came into use. I invented the automatic percussion fuse for rifled projectiles, which made the shells very effective, and some improvements in the shot which adapted them to small rifled guns, in which they were largely used.

In considering this subject, where we have to contend with foreign vessels, and it may be with foreign ports, we have got to look upon it in a different light entirely from the mere use which has been made of rifled guns in the field, because field service and the uses to which a projectile is applied in field service, and the conditions under which it is fired are entirely different from what is intended, as I understand to be meant by heavy guns and heavy projectiles in this examination.

You mean here by heavy guns and heavy projectiles, heavy ordnance, adapted to fortifications and adapted to vessels of war for sea service. That is what it must be taken to mean, and not simply rifled artillery for field service.

For sea service, in considering heavy ordnance, therefore, we have got to consider smooth-bore heavy ordnance, as well as rifled guns, because it will not answer to arm a sea-going vessel entirely with rifled guns, for this reason: The only projectile that will move with accuracy on a ricochet fire on the ocean is a spherical projectile. A rifled projectile will not ricochet with accuracy on the ocean, for the reason that

being elongated and striking the waves with one side it will be deflected off. It will not move with accuracy like a smooth-bore spherical projectile. Therefore, we have got to have heavy ordnance, both smooth-bore and for rifle service, so that we may fire both spherical projectiles and elongated projectiles.

In the contest between the Kearsarge and the Alabama, the Kearsarge with her large 11-inch shell guns fired spherical shells and fuses of my invention. She took care to lay off about nine hundred or a thousand yards from the Alabama, and to fire her shells with a ricochet fire; that is, to let them strike the ocean and bound, so that they would not pass over the Alabama. Being spherical, they would keep the true line of fire and plunge right into the Alabama and explode in her. They never failed to take effect. Whenever they struck her they exploded. We have got to keep up that system, both for fortifications and for the Navy—that is, smooth-bore guns.

A smooth-bore gun need not be as strong as a rifled gun. Therefore, it does not follow that they must be constructed in the same manner. We may have two plans for the construction of this ordnance; one for smooth-bore, because the projectile being lighter will not require a so extraordinarily strong gun—will not require so heavy a charge; but when we come to rifled guns we must have an entirely different construction to stand a very high charge with a projectile of extraordinary weight. Therefore the subject divides itself there into perhaps two branches.

All I have to say in regard to the subject of projectiles is, that pretty much all that can be done in projectiles has been already invented. There is a patent, which I will lay before the committee, which has expired; it was granted in 1860, which embodies all the essential principles of the shell and shot for rifled guns, the mode of constructing it in every way, and there is a model in my hand embodying the same for the large projectile for the same kind of service. There is no further invention open to be made in projectiles. I can show the committee that, and I will file this patent.

But the point is the gun. There are two ways of making these guns, and only two ways. One is to cast the gun of solid steel, all in one piece. Experiments have been made with some improvements which my brother and myself made in that direction; and the specimens of steel tested at the navy-yard when I proposed to go into this matter, some six or seven years ago, stood 60,939 pounds tensile strength, just of cast metal, solid steel, which was double the strength ever before attained in cast metal of steel. We think we can make a 12-inch solid gun of steel, cast upon that principle, which will certainly be strong enough for all smooth-bore guns, and will be strong enough for a very high degree of use and a great many charges of rifled guns.

The CHAIRMAN. Do you mean in casting a steel gun to cast a gun with attachments in separate pieces, or do you mean to take a block of steel and make a gun of it?

Mr. HUBBELL. I mean to cast it right from the molten metal—to cast the gun of steel. We have discovered how to make steel in a molten condition by processes which I proposed to the naval committee some six or seven years ago. I could not get anything done with the matter, though I had samples. There was no disposition to go into the subject of solid guns, it seemed. It is, just to cast the gun, having suitable furnaces with receivers sufficiently large and numerous, the receivers to have sufficient molten metal to cast the gun solid of steel.

Senator ROLLINS. How large a gun can you cast in that way?

Mr. HUBBELL. We can cast a 12-inch rifle-gun. I do not think there is any reasonable limit to the amount of weight, because we can multiply the furnaces, and multiply the receivers in a segment of a circle around the mold to contain any amount of metal that is needed; say, 100 tons of metal to cast a 60-ton gun.

The CHAIRMAN. You have been examining this subject, and have made some calculation as to the cost. What would be the cost of a 12-inch steel gun cast in the way you speak of?

Mr. HUBBELL. Finished?

The CHAIRMAN. Yes, sir; ready for mounting or for testing?

Mr. HUBBELL. That would depend upon the number of guns. The expense would be in the preparation.

The CHAIRMAN. But I am taking for granted that the plant is already secured. Suppose the government had the plant, or an individual had the plant ready to do the work, what then would be the cost of the gun?

Mr. HUBBELL. We could cast the gun alone for 10 cents a pound, perhaps less. It depends upon prices and the localities. We could then finish up the gun for about as much more, I suppose. That depends upon prices, which vary sometimes. It would be as cheap a gun as you could make. I think you could make a finished gun for 20 cents a pound. A gun weighs from 50 to 60 tons; it depends upon the size. Many are over 100,000 pounds.

The CHAIRMAN. I ask as to a 12-inch gun.

Mr. HUBBELL. If you want a gun of great power, a 12-inch rifled gun ought to weigh 50 tons, and that would be 100,000 pounds finished. Multiply that by 20 cents and the result is $20,000. It might cost less.

The CHAIRMAN. Do you believe that a 12-inch gun made of steel can be made for $20,000? I am only asking your opinion.

Mr. HUBBELL. On this plan it can; I do not speak of any other plan of steel guns. I think it could be made for that on this plan of casting it from molten metal.

The CHAIRMAN. If you are through with the theory of the thing, I should like to ask you to give your views to the committee in reference to cast iron, in reference to wrought iron, and in reference to steel in making guns of these three metals.

Mr. HUBBELL. My opinion is that cast iron will not answer at all for heavy guns. It is all nonsense to undertake that for heavy rifled cannon.

The CHAIRMAN. Give us the reason.

Mr. HUBBELL. The reason is that the iron is not sufficiently strong. Another reason is that it is not capable of enduring the constantly repeated firing for so large and expensive a gun. They are not sufficiently strong, in the first place. We have made them on an average about thirty or thirty-one or thirty-two thousand pounds tensile strength. That will stand very well for a smooth-bore projectile, that is a round projectile, because we cannot get over a certain weight in a round projectile. As you increase the weight of the projectile you increase the resistance, and as you increase the resistance you increase the strain on the gun in firing; and, therefore, a cast-iron gun becomes weaker, relatively, as you increase the weight of the projectile. For that reason a cast-iron gun with an elongated projectile, which is necessary for a rifled bore, and which, consequently, greatly increases the weight and greatly increases the strain on the gun, becomes too weak and will not answer. By "cast iron" I mean the ordinary cast-iron gun metal now used of about 30,000 pounds tensile strength.

The CHAIRMAN. What would you say to a cast-iron 12-inch gun or 8-inch gun firing one hundred shots of heavy projectiles?

Mr. HUBBELL. You could not fire one hundred shots with safety. You could not fire ten shots with absolute safety. It would not be sufficiently strong in the first place to use high charges of powder.

The CHAIRMAN. What would you say about wrought iron?

Mr. HUBBELL. The experiments that have been made with wrought iron show that you cannot weld it uniformly, and furthermore it will be impossible to weld in one body—that has been sufficiently demonstrated—sufficient metal to make a 12-inch gun. The gun that exploded on the Princeton was an effort to do that, but it utterly failed.

The CHAIRMAN. You think, then, steel is the only thing a 12-inch gun can be made out of?

Mr. HUBBELL. Steel is the only thing you can make a 12-inch gun out of to stand.

The CHAIRMAN. What do you say to an 8-inch gun or a 9-inch gun, of either cast or wrought iron?

Mr. HUBBELL. It will not answer. It is not sufficiently strong, and not sufficiently certain. Where you have such a very heavy gun and men about that gun whose lives are dependent upon it, there must be no uncertainty about the strength of that gun. A man cannot feel brave and fight bravely when he is alongside of a gun which he apprehends may burst at any moment, and the damage that might result would be enormous. It will not answer.

The CHAIRMAN. I ask you this because during our late war I believe we used almost entirely cast-iron guns.

Mr. HUBBELL. You used what was called the Parrott gun, which was a cast-iron body with a wrought-iron band shrunk at the breech; you used, however, the very small size for field service.

The CHAIRMAN. I am talking about fortifications and ships, not about field service.

Mr. HUBBELL. They were not used on ships successfully at all. They failed. When Commodore Porter undertook to use those guns at Fort Fisher the guns burst.

The CHAIRMAN. What guns do you speak of?

Mr. HUBBELL. The cast-iron rifled gun which was banded. That was the Parrott gun.

The CHAIRMAN. I am not talking about the Parrott gun. I am talking about a cast-iron gun and a wrought iron gun.

Mr. HUBBELL. There were no cast-iron rifled guns used in the Navy except Dahlgren's pattern, rifled, and they burst and failed.

The CHAIRMAN. I know that; that, for instance, the Dahlgren gun was mostly used in the latter part of the war.

Mr. HUBBELL. That was a cast iron shell gun, the same that my projectiles were used in. That was a spherical shell and smooth bore shell gun.

The CHAIRMAN. That was a 9-inch gun?

Mr. HUBBELL. A 9-inch gun, for shooting spherical shells chiefly.

The CHAIRMAN. Was it not the same character of gun that was used by the Kearsarge?

Mr. HUBBELL. The Kearsarge used two 11-inch Dahlgren guns—shell guns.

The CHAIRMAN. They used spherical shot.

Mr. HUBBELL. They were spherical shell guns. They used my 11-inch shells, and you will recollect that a shell compared with a solid shot is light; they will fire solid shot, but not with high charges, nor very

great effect comparatively. Those 11-inch guns used my shells to sink the Alabama.

The CHAIRMAN. I know; but we may be called on in an emergency to use guns, and we cannot make them all of one kind, and what I want to get at is as to the best character of gun now between the wrought-iron and cast-iron gun. You say that steel is the only thing you would make a 12-inch rifled gun of; but suppose you have got to use part rifled and part smooth-bore guns, and you wanted to use a large-sized gun.

Mr. HUBBELL. Then you would have to use spherical projectiles with a smooth-bore gun, and rely chiefly upon the explosive shells with fuses of my invention, now constituting the armament of the Navy and fortifications.

The CHAIRMAN. I am asking only as to the strength of the gun. What do you say of it? Would it be a useful gun—one that could be used safely?

Mr. HUBBELL. We have such guns already. We have the 15-inch smooth-bore guns firing 15-inch shells, and they can fire a few 15-inch solid shot. We have the 11-inch Dahlgren gun. We have on the fortifications the 10-inch columbiad guns, which are very much the same in principle for firing my shells and solid shot. Those guns do very well against wooden ships at almost any distance within their range, which is, say, within a mile and a half. They will not, however, be effective against iron-clad vessels.

The CHAIRMAN. But suppose you are using them against fortifications or using them against a city?

Mr. HUBBELL. Then you may take the present guns with these shells of mine and knock any fortification or city in the world to pieces that you can come up to.

The CHAIRMAN. You have got to fight not only iron-clads but fortifications. Fortifications are not made in the way iron-clads are.

Mr. HUBBELL. No, sir; and there is the point that has driven European governments to build iron-clads. They saw that with these guns which we now have and with these shells we could destroy any of their wooden ships easily, and we could destroy any of their fortifications built of stone or earthworks, and their cities would stand no chance at all. We could burn them up. But then these guns and projectiles, while they are very effective, yet are not absolutely certain against impregnable iron-clads. It is true, with these guns that we have and with these shells, provided you could throw them into the port-holes of an iron-clad, the destruction is terrific; but you cannot always strike a port-hole. Some did in the conflict with the Merrimac go into the ports and produce terrible destruction. If you can batter an iron-clad so as to get any point of penetration and then throw these shells in, the destruction is terrible. They cannot stand it. But the English and the French and other foreign governments have built iron-clad vessels, the object of which is to resist these shells.

Senator CAMERON. How thick is the steel casing in their best vessels?

Mr. HUBBELL. They have them various. They have made them up to 12, 14, and 16 inches. They have tried it to so great a thickness that I do not think a vessel can float the ocean of such thickness throughout.

Senator CAMERON. But vessels that do float—take the vessels that were at Alexandria, what was the thickness of the casing of the largest vessel there?

Mr. HUBBELL. I do not know exactly, but the invulnerable points were over 12 inches thick. They had them thicker at different points,

and they had rifled guns there of enormous power, some 81-ton guns, I think. We have no guns of so great power as those, but some parts of these vessels seemed to be vulnerable. The thickest parts protected the steam machinery and boilers.

The object of this investigation, as I understand it or would apply it, is to attain the construction of guns with projectiles which will be able to cope with those heavy foreign guns and vessels, say in a regular sea fight or in an attack upon their works where they bring those guns, whether in forts or on vessels, into the defense. We must have something sufficiently powerful to cope with them either aggressively or defensively; that is our vessels that go to sea shall have a gun sufficiently powerful to contend with their vessels, even in their own harbors, if that emergency should arise. That is the thing we are aiming at, as I understand. Our powers of defense here at home with these shells and guns that we have are very considerable, unless we are attacked by those iron clads carrying the heavy guns that they do.

Senator CAMERON. Suppose we are attacked by them, how do you propose to defend ourselves?

Mr. HUBBELL. There is the point we shall have to consider.

Senator CAMERON. We have nothing now to defend ourselves with, you say?

Mr. HUBBELL. Nothing that is adequate, that you can certainly rely on. Of course we could make a very good fight with our shells and our guns, because, rather than be conquered, we would run right into them and fire at their vulnerable points and take the chance of being sunk rather than be conquered by them. But that is not what we are aiming at. We want to meet them with guns of greater strength, greater volume, greater power, with projectiles of greater weight than we now have. We can easily make the projectiles. I know all about them; they are all invented; but the point is to get guns that will stand the charge of powder, burn the powder, and yet be sufficiently strong to throw those heavy projectiles and penetrate their iron-clads or crush them. That is what we have to aim at now, and we cannot get up these guns in a short time. We must have a system adopted and the government itself must take the matter in hand, and have the means at its command of manufacturing these guns.

Senator CAMERON. Is there any gun invented anywhere in the world that will penetrate twelve inches of steel?

Mr. HUBBELL. Oh, yes, sir. The English, and French, and Italians have guns that will do it. We have no guns here and no positive plan adopted of making them that will do it.

Senator ROLLINS. Is not the plant in existence here sufficient to construct a 12-inch gun?

Mr. HUBBELL. I think there is a plant here that can construct the steel gun which I propose.

Senator ROLLINS. Where?

Mr. HUBBELL. As I have understood, at the South Boston Works. I think the South Boston Works have a plant; also, the West Point Works. I think they could construct these 12-inch cast-steel guns.

There is another way, however, of constructing a steel gun, and I will submit a plan. That is something upon the plan of what we now call old wire twist gun barrels. The principle was first used in making what we know for small fire-arms as a wire twist. It was a gun made of a series of wires and welded. They welded them to unite them. I can now by a combination make a gun which depends largely for its strength upon steel wire twisted, properly formed, and welded, not

soldered. I will make a drawing of that and submit it, showing how that can be done. That is still a steel gun. Those are the only two ways in which you can do this thing, cast the steel entire and in combination.

The CHAIRMAN. In making this gun, would you make it a breech-loader?

Mr. HUBBELL. Yes, sir; I prefer a breech-loader. I prefer a breech-loader for many reasons. It would be more convenient to load, because it is so long a gun, and would require only short appliances; the men would be more protected; and then another point would be, that by making a breech-loader broad, you make an enlarged chamber for the powder; that is, the diameter of the powder chamber greater than the diameter of the bore of the gun, and you may load it at the breech. The effect of that is to enable you to burn a larger quantity of powder, and to get a higher pressure on the projectile, and therefore move the projectile with a higher velocity, and get a greater destructive effect. That has been tried already in Europe, and found to be the case. It is a well-known fact that if you enlarge the chamber you can burn more powder. Therefore it is best to make a breech-loader.

There is another advantage in a breech-loader for so large a gun, particularly in some of our forts. The most effective fire from a fortification is a plunging fire, because you have the force of gravity aiding or acting with the velocity of the projectile instead of against it; and if we can arm our forts about New York Harbor, and about the approaches to our principal cities, with heavy rifled breech-loading guns, with a plunging fire we can crush any iron-clad fleet Europe can bring here, for we can then strike the most vulnerable parts, because we could strike about the decks. They cannot cover the deck as heavily as they can cover a small portion of the sides.

The CHAIRMAN. Suppose you had a deck covered thus, and every part of the ship the same, would not that resist the same as the side of the vessel?

Mr. HUBBELL. No, they cannot make it so heavy; it would be impossible; the vessel would not float so much metal; and furthemore, if they formed an angle that would be an advantage to a plunging fire, because the shot would strike it more directly. I do not think they could build an iron-clad in that way, for they would have to give breadth of deck in order to get floating power to carry their sides.

The CHAIRMAN. I look upon it as though it was a circle.

Mr. HUBBELL. Still that would not help the matter any; that would make it still worse. The best deck they could present to a plunging fire would be a flat deck, because then the obliquity would be greater, and the tendency to cause the projectile to glance would be greater; but still we can make a projectile to strike that with a plunging fire, and such an enormous power as that gives in every way over and above an elevated fire, that it would be impossible for them to build any iron-clad fleet to float across the ocean that could stand the plunging fire of good fortifications with guns of that kind. They would sink them spite of anything they could do; they could not stand it. I do not think it possible for man to build a vessel that would navigate the ocean and stand a plunging fire of rifled guns constructed as I suggest they should be constructed.

Senator ROLLINS. We might not be able to locate the fortifications in our harbors so as to secure that.

Mr. HUBBELL. We must take care of that. We must select points nearest the channels an enemy must come up. That could easily be

done at New York at the Narrows, and I suppose it could be done at other places. If not, we can build up a foundation for a fort right in the water. We could begin by throwing in the foundation and build it up so as to command the channel.

The CHAIRMAN. Build it with what? Stone?

Mr. HUBBELL. Throw in stone first; get the foundation built of that.

The CHAIRMAN. I could knock that fort down with one twelve-inch shot.

Mr. HUBBELL. Build your stone under water, and build it iron-clad above, and you cannot touch the foundation with any shot.

The CHAIRMAN. I am not talking of the foundation.

Mr. HUBBELL. I understand Senator Rollins' remarks to apply to the foundation for a fort to command the channel, that the channel might be so located that a sufficient natural foundation could not exist, but we can construct an artificial foundation of stone first, and then build an iron-clad fort on top of that stone foundation so as to command the channel. In New York that could readily be done. I do not know about Boston; I am not sufficiently familiar with the channel of that harbor to know what would be necessary, but that is the principle on which to do it. I do not mean to put these guns in stone forts, Mr. Chairman, because, as I have just said, we can take our own guns and shells and knock to pieces any stone fort or any earthwork fort. Therefore it would be useless.

The CHAIRMAN. The best idea would be to get a gun that would go through this iron armor?

Mr. HUBBELL. Exactly.

Mr. CHAIRMAN. And build forts afterwards?

Mr. HUBBELL. Yes, sir.

Senator CAMERON. How far would a 12-inch steel gun, such as you speak of, throw a projectile effectively?

Mr. HUBBELL. We ought to build a 12-inch steel gun that would throw a projectile five miles.

Senator CAMERON. And do effective work?

Mr. HUBBELL. Do effective work—that is, with an explosive projectile. Of course you could not do very effective work against an iron-clad over a thousand or fifteen hundred yards for penetration, the velocity diminishes so rapidly; but the projectiles in many actions would be very effective for different purposes against forts or encampments or cities, if it was necessary, any distance within five miles. We could make shells to explode. There is a patent in my hand, granted to me in 1860, for that automatic explosive shell which was used in the field service, and I can explode that shell with certainty five miles off with terrible power. But then, while the gun would be useful for that, we at the same time want a gun that will have a high penetrative power of a great projectile at say a thousand or fifteen hundred yards, to penetrate these iron-clads, and it is idle for us to rest until we get that gun. The government ought to have the means of manufacturing that gun at its command at any time. It will not answer to take the chances in these times of being able to get up a gun against foreign nations who are already armed, and this government cannot under the most favorable circumstances do anything effective under one or two years. We should have our cities reduced to ashes, and be blown out of the water, as the saying is, in six months, if we were in such a defenseless condition as that.

Senator CAMERON. If I understand you correctly, if one of these foreign iron-clads, such as are now being built in England and in Italy,

should come within five miles of the city of New York, it could throw shell into it, and destroy the city; and the best way to meet it is with a 12-inch gun, such as you propose to make, and to go out within 1,200 yards and attack them?

Mr. HUBBELL. Yes, sir; 12 inch, or larger.

Senator CAMERON. Therefore, the gun would be of no consequence in a fortification as against these vessels?

Mr. HUBBELL. We ought to have the guns in the fortifications, too.

Senator CAMERON. But they could stand off from our fortifications and destroy the city, and unless we had something to go out and meet them, we could not destroy them. We could not destroy them from fortifications unless they come up to the fortifications.

Mr. HUBBELL. We could not destroy them from fortifications unless they come within a reasonable range of the fortifications. It would depend very much on the distance of the fortifications from the city, whether they would be able to engage those vessels before they got within range of the city. In other words, if the fortifications were nearly two miles from the city, the iron-clads might lay off four miles and throw clear over the fortifications into the city, and shell it, unless we also had vessels to go out and engage the iron-clads. Therefore, the distance of the fortifications from the city as an element of defense enters into that problem.

Now, the whole question comes down to this: We have got to construct heavy ordnance. By heavy ordnance I mean about 12 inches in diameter, capable of throwing solid shot whose length is about 2½ diameters of that, 2 feet 6 inches long from one extremity to the other. We have also got, in order to keep up our American system of ricochet fire at sea, that is, firing when the gun is on the depression so that the projectile may strike, to construct large size smooth-bore guns, because that ricochet fire can only be maintained in its accuracy with spherical projectiles. We should have, therefore, both kinds of guns, smooth-bore and rifled guns, of large caliber and of very great tensile strength. The tensile strength should be not less than 60,000 pounds to the square inch, and with properly constructed wire or steel bands and the cast-steel gun body the tensile strength may be increased to over 100,000 pounds per square inch. We should have both of these kinds of guns constructed.

ADDITIONAL STATEMENT OF WM. WHEELER HUBBELL.

DECEMBER 30, 1882.

Mr. HUBBELL. Since I addressed the committee I have seen the printed report of the Ordnance Board. I had a conversation with that Board, but did not submit any plan, for numerous reasons which I stated to them and need not repeat here now.

I will submit in writing my statement with accompanying drawings. I adopt the Ordnance Office plan M with certain modifications. While I select that as the proper model for a gun, I disapprove entirely of the recommendation of the Board as to other modifications or plans of guns.

The CHAIRMAN. What board?

Mr. HUBBELL. The Board of Ordnance that convened in New York City this last year called the Getty Board.

It is not necessary for me to continue any verbal remarks, as I have condensed in writing my proposition, and the reasons why I did not present the plan to the Board. I now submit the statement.

[Forty-seventh Congress, Second Session.]

To the honorable the Committee on Heavy Ordnance and Projectiles, appointed by the Senate of the United States of America.

The undersigned, William Wheeler Hubbell, a citizen of the United States, formerly of the State of Pennsylvania, now of Appomattox County, State of Virginia, respectfully submits the subjoined statement and proposal on the subject of heavy ordnance and projectiles, with exhibits appended.

PLAN NO. 1.

William Wheeler Hubbell presents to the committee for trial the plan of gun, marked M, presented by the Ordnance Office to the Board on Heavy Ordnance and Projectiles, and by them recommended for trial with the following modification and improvement now proposed, to wit: That instead of the body of the gun being made of ordinary cast iron, that the body of the gun be cast of the refined cast iron carbonized (or steel) described in the letters patent of said Hubbell & Brother, No. 150,576, dated the fifth day of May, 1874, in order to increase the quality and strength of the cast metal, both transversely and longitudinally; also, that the steel bands in the plan be screwed on when hot, in order to increase the longitudinal strength of the gun; that otherwise the plan remain as it is presented.

PLAN NO. 2.

Second. Adopting the same model and proportions of exterior, length, bore, and chamber, that the entire gun be cast of this improved cast-iron, metal or steel, in accordance with the said Hubbell patent, substantially, so as to obtain a gun not simply of about 30,000 pounds of tensile strength, but of 60,000 pounds or upwards per square inch and solid.

PLAN NO. 3.

Third. Adopting the same model and proportions of exterior, length, bore, and chamber, that the main body of the gun be cast of this improved cast-iron metal or steel, in accordance with the said Hubbell patent substantially, excepting the steel bands and screw fermeture, and that in place of the outer series of bands, the casting be reinforced with steel riband of screw-thread formation, wrapped and welded on the plan and invention of said William Wheeler Hubbell, and with the balanced breech-fermeture and gas check of said Hubbell plan, substantially as patented 7th April, 1874. The object of this modification being to greatly increase both the longitudinal and transverse strength of the gun, for heavy charges, with ease and facility of loading, and rapid firing, without exposure of the working parts of the breech mechanism to interference or injury, the plan of the same being marked No. 3.

WILLIAM WHEELER HUBBELL.

That to carry into effect the manufacture of the three specimens of this model of gun, the sum of $100,000 be appropriated.

In this connection it may be remarked that the "cast iron" referred to by the Ordnance Office, and the "Getty Board," by the use they make of that term, means the state of the art of refining and casting iron in 1865, which for gun-metal, then, was about 30,000 pounds tensile strength per square inch. Witness as follows: Letter of January 26,

1882, from Chief of Ordnance to the Board, pages 28, 1282 of their report, to wit:

In this connection I would call the attention of the Board to the statements and remarks published in "Ordnance and Armor," by Holly, pages 308 to 327, and pages 331 to 334. It will scarcely be claimed that any material improvement has been made in the production of cast-iron guns since the date (1865) of that publication; cast iron at that time had reached its hightest standard.

And the Board says, page 17:

Though the experience of our own country has shown that heavy guns, possessing moderate power, can be made of cast iron solely, we do not regard it as a reliable metal for our seacoast armament. We have, however, recommended for trial two cast-iron guns, banded with steel rings and one wrapped with steel wire, with a view to determining their suitableness for supplying, in case of urgent need, a deficiency in the armament of our forts and batteries, and with the belief that such guns can be produced at our own manufactories without much delay.

From these official remarks it is evident that what the term "cast iron" means in them is, the ordinary gun-metal cast iron, well known to be only about 30,000 pounds of tensile strength to the inch, and impure to a high degree, as it contains sulphur, phosphorus, silica and carbon.

The improved cast iron or steel proposed by the Hubbell system is purified of sulphur, phosphorus, silica, and excess of carbon, until so little carbon is contained in it as to become steel in a technical sense, although refined in a molten condition, and originated as a patent in 1874, nine years after the time of cast iron alluded to (1865) by the report.

A charter (bill S. No. 803, Forty-third Congress, first session) was asked for of Congress in 1874, by Mr. Hubbell, for a corporation to make ordnance, &c., under these and other metallurgical discoveries, but neither this nor the royalty claimed and established as due to him for projectiles used by the United States in the late war was or were allowed or paid; consequently, of course, this discovery has rested, and the heavy ordnance not made for the United States.

In the mean time, England and Germany have utilized this discovery in the manufacture of steel; and in a treatise on "A Bar of Iron" by George W. Von Qunzelmann, copied in January, 1883, number of the Leslie Magazine, exhibiting great knowledge in the working of iron and steel. It is also specified, to wit:

In 1878 Messrs. Thomas and Gilchrist showed that phosphorus may be eliminated in the Bessemer process by lining the converter with lime instead of with ganuister, or even by simply adding lime to the contents of the converter. By the utilization of this discovery, the Bessemer process has been successfully applied both in England and Germany to the manufacture of wrought iron and steel form very inferior qualities of cast iron.

Here, then, is the principle of using lime with oxygen amongst the molten iron in a receiver covered by the fourth claim of the Hubbell patent process, demonstrated in England and Germany on their inferior iron; relatively proving that it will make superior steel of superior iron.

This cast refined iron or steel has been made of 80,000 pounds tensile strength by Mr. R. H. Hubbell.

A conversation on the subject was had with the Board on August 1, 1881, at which time Col. J. G. Benton was a member; and owing to his death soon after, the Board lost a most able adviser on the subject. And a resolution of the Board, to wit (page 48):

That the Board select from the various projects before it of "cast-iron guns, pure and simple, one that fairly represents the whole, and recommend a 12-inch gun for construction and trial" being offered,

The resolution was not adopted.
Noes: Major Mendenhall, Colonel Tower, and General Getty—3.
Ayes: Major Parker and Lieutenant-Colonel Buffington—2.
Lieutenant-Colonel Buffington and Major Parker gave the following reasons for their votes:
1st. The experiment would not be costly, and there are *improved methods of casting* claimed to remove certain weaknesses inseparable from *cast-iron guns.*
2d. Powders and projectiles have been improved to give more uniform results and less destructive effects on guns.
3d. It is only by actual test of a large gun under these improved conditions that the suitability of cast iron for heavy ordnance can be known, and its comparative merits with other metals and systems of gun construction determined.
4th. The trial of a cast-iron gun, pure and simple, may furnish useful information in regard to cast iron in combination with other metals.

If the minority here meant in their first reason that the cast iron used should embrace the improvements in refining made since 1865 they were right, and it is probable that the majority meant by "cast iron" the ordinary gun metal of 1865 alluded to by the Chief of Ordnance, before referred to.

This applicant did not present any plan of gun to the Board, nor incur any expense on the subject, it being impracticable to incur further expense in relation to heavy ordnance and projectiles until Congress has fully paid the royalty due this applicant for projectiles used heretofore in war. It is impossible for citizen inventors to bear such onerous burdens as Congress imposes upon them, in this instance, at least, by non-payment of past dues fully and promptly.

This improved gun metal for heavy ordnance and projectiles has thus laid for eight years, without the United States making any advance in the attainment of means of defense commensurate with the advances made in Europe in this same direction, and the question is now again presented as to what Congress will do on this subject.

In the mean time, not only is the naval and sea-coast defense relatively on the decline, but the commercial marine is not progressive; for it is manifestly hazardous for merchants to build ships to be unprotected in time of war, perhaps for commercial supremacy, in which they become the objects of prize. Congress alone can make progress in relation to heavy ordnance and projectiles, in either one of two ways.

One is, to pay the royalties due to this applicant, amounting to $100,000 in the percussion shell fuses used in the late war, and $30,000 in the metallic ammunition made, in which event this applicant will be enabled to make an 8-inch heavy rifled gun as his own for trial. The other way is, for Congress to appropriate $100,000 for the making and trial of the three guns embraced in this proposition.

This applicant has carefully examined all the other plans of guns proposed by the Board, and inasmuch as it has already been fully demonstrated by the Ordnance Department that the tubing of ordinary cast iron with steel or wrought iron is an advantage, and can be applied to any of the cast-metal guns, none of the other plans suggested are, in his judgment, sufficient to justify the expenditure of any money, for many reasons:

1. Their parts are too numerous, and metallurgically are too diverse for homogeneity and resistance. They exhibit too many weak points, liable to rupture.

2. As to the compound gun of steel, copper and tin, or bronze, that forms a voltaic pile, and as the steel becomes magnetized the bronze must become decomposed and weaker. The proposed longitudinal bars diminish the transverse strength. The Armstrong guns (page 284–285) are a better plan of wrought steel and wire gun.

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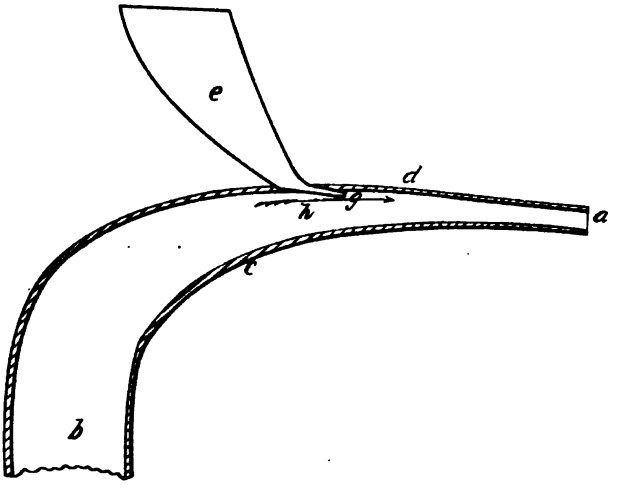
No. 4

W. W. Hubbell.

Refining Iron and Steel.

No. 99,677. Patented Feb. 8, 1870.



Witnesses:
Joseph Sargent
John White

Inventor:
Wm. W. Hubbell

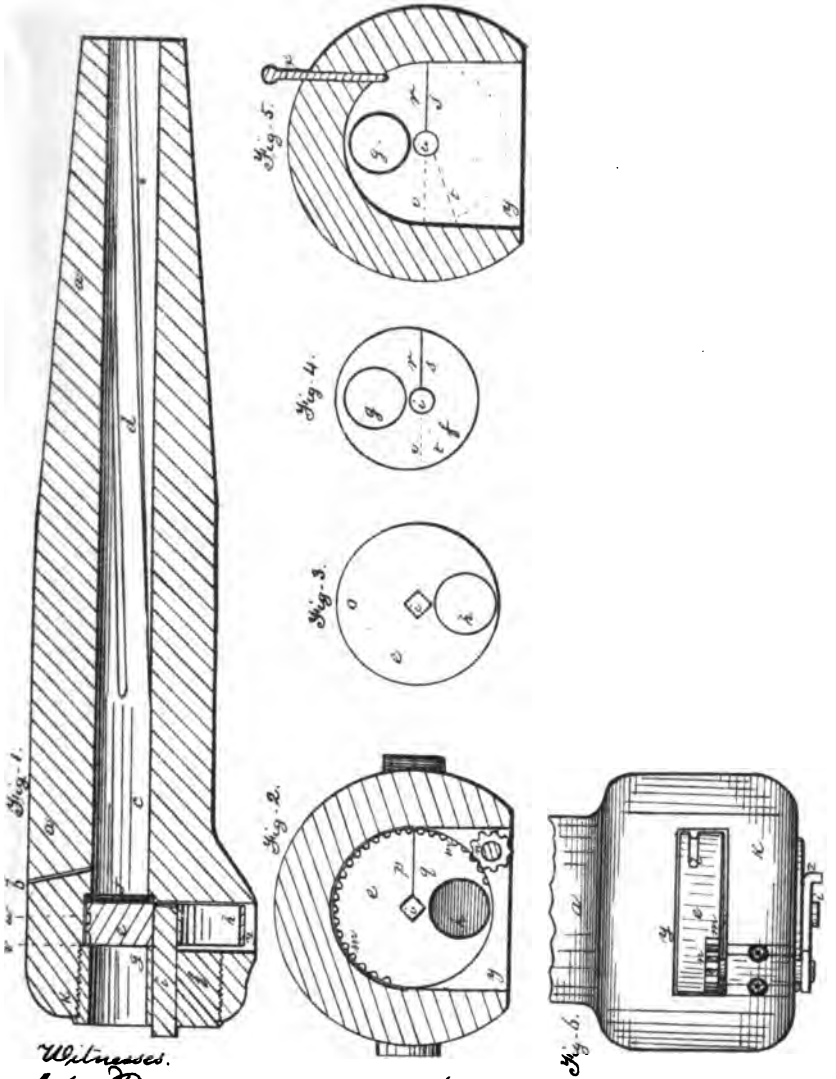
S. REP'T 969, 2, 47.

No. 5.

W. W. HUBBELL.

Breech-Loading Ordnance.

No. 149,478. Patented April 7, 1874.



Witnesses.
John Thorn
E. A. Mills

Wm. Wheeler Hubbell
Inventor.

S. REP'T 969, 2, 47.

No. 6,

Sheet 1 - 2 Sheets.

W. W. Hubbell.

Projectile.

No. 28084. Patented May 1. 1860

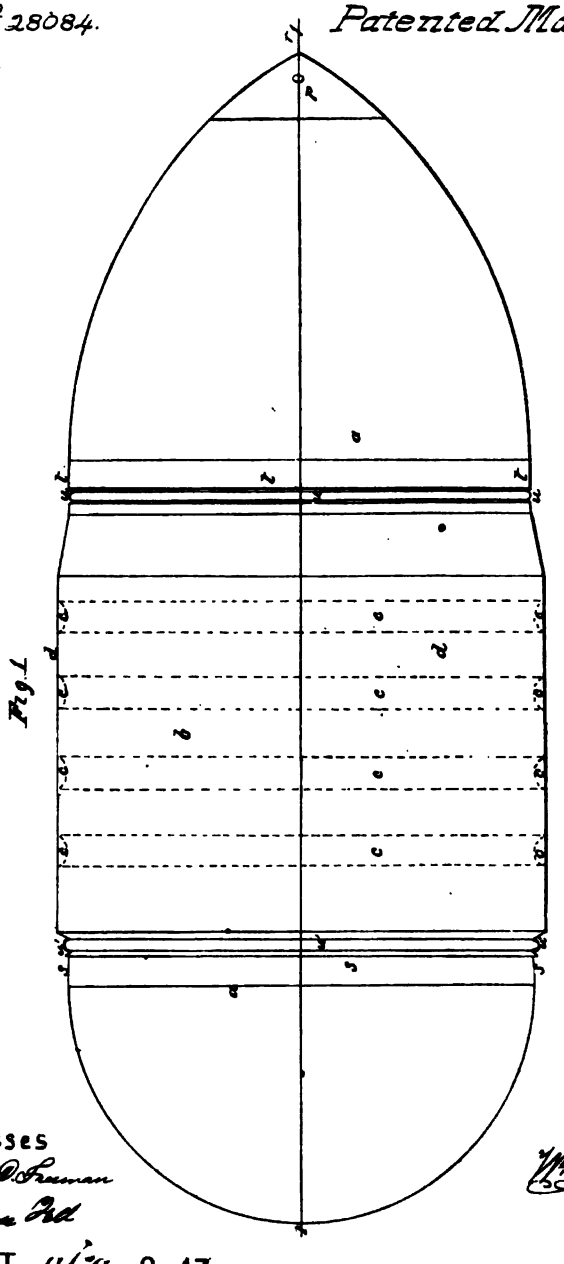


Fig. 1

Witnesses
Chas. D. Freeman
Wm. Dell

Inventor
Wm. W. Hubbell

S. REP'T 469, 2, 47.

No. 6,

Sheet 2 - 2 Sheets

W. W. Hubbell.

Projectile.

No. 28084 Patented May 1. 1860

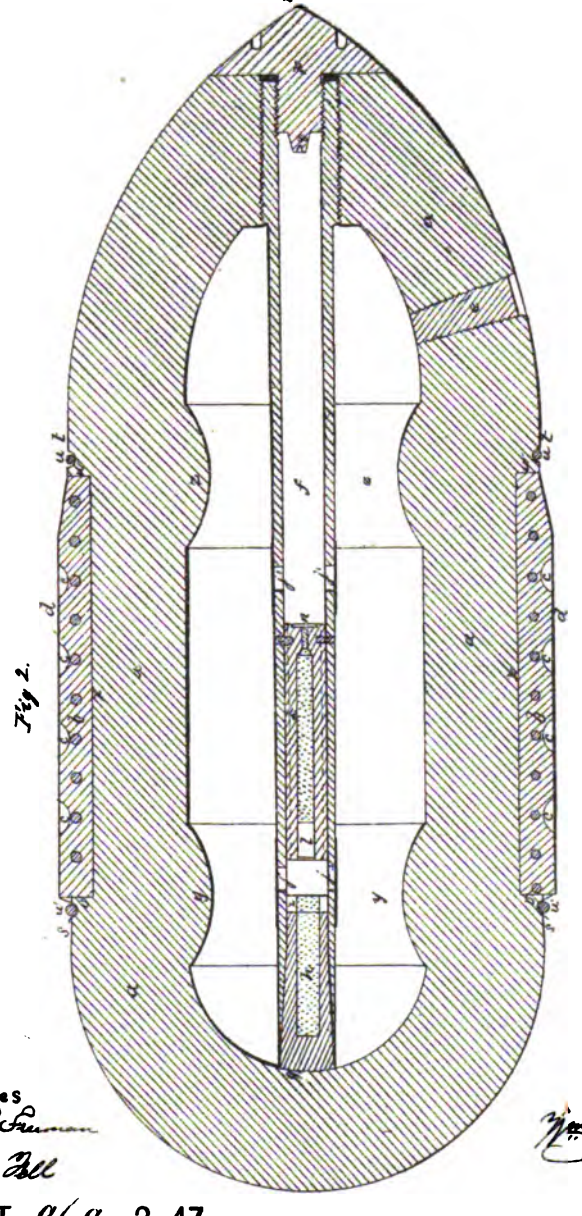


Fig 2.

Witnesses
Chas. D. Simmons
Samuel Hill

Inventor
Wm. W. Hubbell

S. REP'T 969, 2, 47.

3. The trials suggested by this applicant of the Plan M, of the Ordnance Department, modified into three guns, No. 1, No. 2, and No. 3, proposed by this applicant, would test every practical feature of the subject of heavy ordnance that can now be made in the United States, and the probability is that all three of the guns would answer, they differing only in the cost.

4. This applicant has never subjected the United States to any expense for trials of heavy ordnance. He made his own experiments in this direction at his own expense, knowing that metallurgical chemistry would furnish the solution of success. The use made by the United States of his inventions in projectiles adapted to heavy shell guns, and ordnance also for solid shot, has amounted to millions, and he has confined his efforts therefore, first, to get Congress *to justly pay him for what has been used;* and in now making this proposition he greatly regrets that Congress has not dealt with him justly by making actual full payment to him, and also that so much money has been heretofore spent in a fruitless effort to obtain stronger heavy ordnance.

This applicant believes that successful citizen inventors have a just right to full compensation without oppressive suits, exactions, and delays, and also to a fair trial of inventions adapted to the public service.

Having had occasion to express these sentiments for the information of Congress, he respectfully submits his proposal on this subject of stronger heavy ordnance for trial.

THE PRESENT HEAVY ORDNANCE OF THE UNITED STATES.

The 15-inch guns of the United States now in service, cast at the Scott foundry, Reading, Pa., were made under the supervision of my brother, Richard Henry Hubbell, who is a co-inventor with me and patentee in the Hubbell steel. We have as our private property the formulations of various metals used in the casting of those 15-inch ordnance, together with the respective tensile strengths. He directed the mixing and the condition of the metal in the casting. We are therefore the practical men who have already cast the heaviest United States ordnance in use, as well as the discoverers of the formulations and processes to increase the strength of the metal as high as 80,000 pounds to the inch. The 15 inch guns averaged full 31,000 pounds tensile strength. The whole formulations and processes are our private property, not the government's.

Truly,

WM. WHEELER HUBBELL.

Post-office, Concord Depot, Virginia.

EXHIBITS.

No. 1 M, No. 2 M, No. 3 M. Plans of guns for trial.
No. 4. Specifications of patents for cast metal.
No. 5. Specification of patent for breech-loading device.
No. 6. Specification of patent for breech-loading projectile submitted herewith. Plan of shell, solid shot on same principle, with cutting points.

ADDITIONAL PROPOSAL.

The undersigned has filed a description of the new 100-ton Armstrong gun of Great Britain, to show the present state of the art in Europe, and also proposes to construct a 100-ton gun of the Hubbell steel, with the Hubbell balanced block fermeture, in similitude of the plan No. 3 M, but to be 15 inches in the bore (instead of 17, as in the English gun), but otherwise of the same dimensions; to stand a higher charge and throw the projectile with greater initial velocity, and a superior projectile, and thus surpass the English gun in effective penetration or power; the cost of this proposed gun to be $50,000, or 25 cents a pound.

WM. WHEELER HUBBELL.

UNITED STATES PATENT OFFICE.

William W. Hubbell, of Philadelphia, and Richard H. Hubbell, of Chester, Pennsylvania. Improvement in processes of purifying and strengthening iron in a molten condition for casting.

Specification forming part of letters patent No. 150,576, dated May 5, 1874; application filed April 25, 1874.

To all whom it may concern:

Be it known that we, William Wheeler Hubbell, of the city of Philadelphia, State of Pennsylvania, and Richard Henry Hubbell, of Chester City, Delaware County, and same State, have invented an improved process of purifying and strengthening iron in a molten condition for casting into a mold, of which the following is a specification:

This invention relates to that class of processes employed for purifying and strengthening a molten mass of iron to be cast and solidified in a mold, or otherwise employed in the manufacture of iron.

In carrying out our invention, take of nitrate of potash, or saltpeter, one pound; of pulverized lime, one pound; of fine chloride of sodium, or salt, half a pound; of pulverized charcoal, half a pound; of pulverized clay, three pounds. Mix them together with about a pint of water, forming a thick wash or matrix. Place this matrix into and around the bottom of a receiver, into which the molten iron is to be poured, washing it or spreading it over the bottom, so that it adheres thereto, and let it nearly or quite dry. Smelt the iron in a furnace in any manner to make it as pure or refined as possible.

We recommend the process patented by William Wheeler Hubbell, February 8, 1870, and improved and patented by him April 21, 1874, of record in the Patent Office.

When the iron is smelted in the furnace, draw off about seven hundred pounds of the molten iron, and pour it into the receiver containing the matrix upon the same, and let it flux; then remove or keep back the flux, and pour the iron into a mold of any desired shape. The mold may be a green-sand mold, a dry-sand mold, or a chill-mold, depending upon the article to be made, and the time and facilities for doing the work, as is well known. The iron may be drawn from the furnace direct into the receiver containing the matrix, but is less liable to permeate all of the iron, as it enters more slowly.

To cast large masses of iron in one mold, a series or sufficient number of receivers containing each a matrix must be used, and the quantity and proportions for each receiver may be varied more or less, and increased for very impure iron. Nitrate of soda may be used with or as a substitute for nitrate of potash, or saltpeter, to develop oxygen, and alkaline matter, with pulverized borax with or as a substitute for the lime and salt, to develop a flux to unite with the silica and alkaline

matter, to prevent oxidation of the particles as they solidify; and carbonate of soda may be used with or as a substitute for the chloride of sodium in the matrix of clay.

This invention is an improved economical method of carrying into effect on a smaller scale the principles heretofore discovered and patented by William Wheeler Hubbell, and we contemplate using the pulverized lime and salt, or carbonate of soda, as a substitute for the pulverized borax mixed with the saltpeter by means of the tube *e*, described in his patent of February 8, 1870, No. 99,677, and by means of the cast iron cases described in his patent of April 21, 1874, in case the borax becomes too expensive or scarce, using the atmospheric air to force these ingredients among and into the molten particles of iron in the furnace, and thus obtain the iron as pure as possible from the furnace at the least expense. The proportions of the ingredients and of iron may be varied without changing our invention.

The development of the gases from the matrix of clay, compounded as described, forces upward into and among the molten particles of iron in the receiver the flux and alkaline matter formed by the clay, lime, and salt, and the oxygen gas unites in the combustion of the sulphur, phosphorus, and carbon. The chlorine assists the union of the flux with the silica, purifying the iron; and the alkaline matter prevents oxidation of the particles of molten iron, and they unite on solidifying, when cast into a mold, with great purity and strength. The pulverized charcoal may be omitted, but it assists to support the combustion in the separate receiver, and slightly carbonize or soften the iron. We do not confine ourselves to the proportions of ingredients stated.

We do not claim lining the bottom and sides of a receiver, or either of them, with a wash or dough of binoxide or hyperoxide of black manganese, with or without sesquioxide of iron, water, and carbonate of soda; nor of introducing gas or matter into the iron by a lining to the receiver, as that method has been long known.

What we claim is—

1. The composition for purifying and strengthening iron, consisting of a matrix of clay, saltpeter, lime, salt, and charcoal in the bottom of a receiver, upon which the molten metal is poured and allowed to flux, as described.

2. The composition for purifying and strengthening iron, consisting of a matrix of clay, saltpeter, lime, and salt in the bottom of a receiver, upon which the molten metal is poured and allowed to flux, as described.

3. The combined process of purifying and strengthening iron, consisting of driving, with and by means of atmospheric air, into and among the molten iron in the furnace, a compound of pulverized lime and salt, or equivalent flux, and alkaline matter, and drawing off and pouring the molten iron upon a matrix of saltpeter, lime, salt, and clay, allowing it to flux, and pouring the iron into a mold, as described.

4. The process of purifying and strengthening iron, consisting of driving, with and by means of air or oxygen gas, into and among the molten iron, a compound of pulverized lime and salt, and allowing it to flux the iron in the furnace or separate receptacle, as described.

WM. WHEELER HUBBELL.
RICHARD HENRY HUBBELL.

Witnesses:
JNO. E. CLYDE,
G. MORRIS.

UNITED STATES PATENT OFFICE.

William Wheeler Hubbell, of Philadelphia, Pennsylvania. Improvement in refining iron.

Specification forming part of letters patent No. 150,042, dated April 21, 1874; application filed April 2, 1874.

To all whom it may concern:

Be it known that I, William Wheeler Hubbell, of Philadelphia, Pennsylvania, have invented an improved process of purifying and strengthening iron, to form a welded cast iron when solidified in a mold, of which the following is a specification:

My present invention is an improvement upon the process of smelting and refining iron patented by me on the 8th of February, 1870, reference being had to the specification and drawing annexed to said patent of record in Patent Office.

The nature of my present invention consists in the process of purifying and strengthening the iron, consisting of the treatment of the particles of the molten mass of iron and of melting iron in the furnace or a separate receiver with borate of soda or borax pulverized, nitrate of potash pulverized, and atmospheric air, in the manner herein described. The nitrate of potash purifies and the borax strengthens the iron.

The manner of using the nitrate of potash to refine or purify the iron in the furnace is fully described in the specification of my said patent of 8th of February, 1870, but is not combined with the present strengthening process.

The present improved process to strengthen the iron is varied somewhat in degree, according to the quality of the iron to be acted upon and the quality desired to be produced, and is to be carried on wholly or partly, as will be described, as the iron is to be more or less purified and strengthened, at one smelting, or in successive smeltings. The process of strengthening the iron consists in forcing pulverized borax, with and by means of atmospheric air, in direct contact with the particles of the melting iron in the furnace and into or among the particles of the mass of molten iron in the furnace, and in a separate receiver, the iron having been sufficiently refined or purified by any process, thereby giving it great strength when cast into a mold; also, of purifying and strengthening the iron by forcing a compound of pulverized nitrate of potash or its equivalent and pulverized borax or its equivalent, with and by means of the atmospheric air, into the particles of melting iron and molten mass of iron in the smelting furnace, to both refine or purify and to strengthen the iron, as described herein more particularly.

I carry the process into effect in several ways. I supply some of the pulverized borax within cast-iron cases, placed with the iron and fuel inside of the furnace in charging it, to melt at the fusion point in the furnace, and the borax be scattered by the air blast among the particles of melting or melted iron. Also, I mix or compound pulverized nitrate of potash and pulverized borax and force them, with and by the atmospheric air, through the feed tube *e* and tuyere, as the niter alone is supplied, described in my said patent of February 8, 1870, and unnecessary to be repeated in detail here. Also, I force the pulverized borax, by and with atmospheric air, into and among the particles of the molten mass of iron when drawn off from the furnace into a separate receiver, and thus most effectually both purify and strengthen the iron when cast into a mold.

The manner of supplying the pulverized borate of soda to the air pipes, blast pipes, or tuyeres is by means of the tube *e*, described in my said patent for smelting and refining iron, to enable the passing current of air to suck or draw the pulverized salts into the air pipe or tuyere and force it into the furnace. When the borate of soda is supplied in shells or cases the filling hole of the shell or case is stopped with clay, and each case is about half an inch thick, and contains about four pounds of the borate of soda. At the same time nitrate of potash or nitrate of soda is supplied by the tube, as described by the specification of the patent of 8th of February, 1870; and a portion of borate of soda should be mixed with the nitrate of potash—about one part of borate of soda to two parts of nitrate of potash—supplied through the air pipes, and two parts of borate of soda in the cast-iron shells or cases. A proportion of twenty pounds of nitrate of potash, mixed with ten pounds of borate of soda, and supplied through the air tube, and with twenty pounds of borate of soda in the cast-iron cases inside of the furnace to each ton of iron of two thousand two hundred and forty pounds is a good proportion; but these proportions may be changed, and increased or diminished in quantity, to suit different irons and mixtures of irons, and different degrees of refining and strengthening required.

The iron is refined by the oxygen of the niter combining with the carbon, sulphur, and phosphorus, and burning them out, and the borate of soda combines with the silica, which separates from the iron in a flux, and the alkaline matter prevents oxidation of the granules of the iron, and causes them to weld or form into a welded cast iron of great purity, density, and very great tensile strength.

Carbonate of soda may be used in the cases or air tube; but it is inferior to borate of soda in forming a flux with the silica to free the granules of the iron and make them weld.

I supply the nitrate of potash and borate of soda or borax mixed together, with the atmospheric air, by means of the feed-tube *e* and tuyere, described in my said patent No. 99677, dated 8th February, 1870, because the supply is in small particles or quantity at a time, and acts immediately, and cannot produce an explosion; but the borax is supplied alone, without the niter, inside of the iron cases set within the furnace, because the niter, if supplied in these cases inside of the furnace, would prematurely blow out, by development into oxygen gas in heating, or cause an explosion. To force the pulverized borax, with the air, among the molten particles of iron, held in a receiver separate from the furnace, I feed the pulverized borax, with a slide or measure, from a box into an air pipe leading to near the bottom of a receiver containing the molten iron, and the pulverized borax is, by and with the air, forced into the particles thereof, to further strengthen the iron; and at this operation pulverized niter, in a small quantity, is also mixed with the borax, and forced by the air with it, to further purify the iron, if it is not previously sufficiently purified. The sliding measure is a flat piece of iron about six inches square, with a cavity one inch wide and three inches long, cut through it in the middle. It slides between horizontal plates under the box of pulverized salts, to receive the borax and niter, and then forward between the plates of sufficient width into the air tube extending down, and the air, passing down through the aperture, carries the pulverized salts with it into the molten iron. The iron must be nearly pure to strengthen it most effectually by this process, with air and pulverized borax; and any other process of purifying it, besides the use of niter, may be employed with the air and pulverized borax The air itself also purifies it some, or the iron may be previously puri-

fied. To slightly carbonize the iron when desired, supply the carbon by pulverized charcoal or other material, with the air, through the feeding slide into the iron in the receiver, or otherwise carbonize it in any of the well-known methods.

It is unnecessary here to repeat the disclaimer contained in my said patent of 8th of February, 1870; neither do I claim borax to weld bodies of iron or steel, as it has been long used to aid in the welding of bodies of iron and steel in making tools and machinery; but I have discovered that a sufficient quantity of pulverized borax forced among the particles of a molten mass of purified iron, with and by means of atmospheric air, will cause the granules of iron in the act of solidifying to weld or unite with great adherence, and form a cast iron of superior tensile strength.

I claim as my invention—

1. The process of strengthening iron, consisting in forcing pulverized borax, with and by means of atmospheric air, among the particles of molten iron within the furnace or a receiver, substantially as described.

2. The process of purifying and strengthening iron, consisting in forcing a mixture of nitrate of potash and borax pulverized, with and by means of atmospheric air, among the particles of molten iron within the furnace or receiver, substantially as described.

3. The process of strengthening iron, consisting in forcing the pulverized borax, with and by means of the atmospheric air, into or among the particles of molten iron within the furnace, the borax also being supplied within fusible cast-iron cases inside of the furnace among the fuel and iron, substantially as described.

4. The combined process of purifying and strengthening iron, consisting in forcing the nitrate of potash or a compound of pulverized borax and nitrate of potash, with and by means of the atmospheric air, from the outside through the feed-tube and tuyere, and from the inside within and by means of the iron cases containing borax alone, into and among the molten iron within the furnace, substantially as described.

5. The combined process of purifying and strengthening iron, consisting in forcing the pulverized nitrate of potash and pulverized borax mixed, with and by means of atmospheric air, into the furnace, and with the fusible iron cases containing the borax within the furnace, among the particles of molten iron, and in forcing pulverized borax with the air among the particles of the molten iron contained in a separate receiver, substantially as described.

6. The process of strengthening iron, consisting in supplying borax, within fusible cast-iron cases inside of the furnace, to and forcing it among the particles of molten iron, with and by means of the atmospheric air, substantially as described.

WM. WHEELER HUBBELL.

Witnesses:

HENRY H. BURTON,
A. E. BEECHER.

UNITED STATES PATENT OFFICE.

William W. Hubbell, of Philadelphia, Pennsylvania.—Letters patent No. 99677, dated February 8, 1870.—Improvement in smelting and refining iron.

The schedule referred to in these letters patent and making part of the same.

Be it known that I, William Wheeler Hubbell, of the city of Philadelphia and State of Pennsylvania have invented a new and useful im-

provement in the method of smelting and refining iron and iron ore and other metals or metalliferous ores, and I hereby declare the following to be a full, clear, and exact description thereof:

The nature of my invention consists in supplying pulverized saltpeter to the blast-pipes or tuyeres of the furnace in which the iron or ores is or are being melted, so that this pulverized saltpeter shall be driven with and by the blast into the furnace, in direct contact with the melting iron or ores, or close to the surface of the molten iron. This pulverized saltpeter, being in fine particles, readily enters into combustion with the sulphurous and carbonaceous matter in the furnace, and so largely frees the sulphur from the iron that it becomes thereby highly purified, and is rendered strong or tough and tenacious. It also makes it more readily convertible into steel. Iron thus prepared becomes important for the manufacture of large guns or ordnance, which should be cast from a furnace in which the smelting operation is conducted by the use of saltpeter in this manner. Nitrate of soda, pulverized, as well as nitrate of potash, may be used in this manner to smelt the iron, or other pulverized salts which evolve oxygen when brought into contact with the fire in the furnace may be used.

Various common mechanical devices may be employed to measure and deliver the saltpeter into the tuyere or tuyeres of the furnace. I introduce it by means of a tube entering into the top of each tuyere, the tube sloping or inclining in direction toward the furnace, by which inclination the passing current of air in the tuyere sucks or draws the pulverized salts into the tuyere. The tube should enter the tuyere about half an inch.

The pulverized salts is measured into the tube from a box above, containing it, by a sliding bar, containing a chamber or chambers, which receive the powder, and drop it into the tube close to its mouth. Various other modes of measuring the powder into the tuyere may be employed—namely, a wheel with chambers in its periphery, or through its sides, may be employed to measure the salts from the box; also, a plunger may be used to force the salts into and along the tube into the tuyere. The supply-tube should enter the tuyere on the top of its barrel portion, between the bend and its nozzle or mouth, so that the air shall not drive the powdered salts back into the supply-tube.

About twenty pounds of salts may be used in smelting one thousand pounds of metal, though more than this quantity may be used. I do not mean to confine myself to any particular proportion of salts, nor to any particular device to supply it to the tuyere or tuyeres. Each tuyere should have its own feeding device.

By using one hundred pounds of the powdered saltpeter to one thousand pounds of iron, will decarbonize the iron and convert it into steel or malleable iron, or into more or less refined cast iron, dependent upon the quantity and kind of fuel used, which may be charcoal, or anthracite or bituminous coal, or other fuel.

Another method of supplying the saltpeter to the tuyeres, so that they may direct it with the blast into the furnace, and which is well suited to the cupola-furnace for smelting pig-iron, where a fan-blower is used, is to feed the powdered saltpeter in at the eye or side of the fan-blower, by means of a hopper and shoe, by shaking them in the usual manner of feeding flour or grain. The mouth of the shoe is placed close to the side or eye of the fan-blower, and the air, entering there, sucks or draws the powdered saltpeter with it, and forces it through the tuyeres into the fire of the furnace.

The annexed drawing represents a sectional view of one of the tuy-

eres, with the small pipe to feed the saltpeter through into it, in which *a* is the discharge-mouth or nozzle of the tuyere, *b* is the portion leading to the blower, *c* is the lower and *d* the upper side, and *e* is the pipe to feed the pulverized saltpeter, *g* being its mouth, which is directed toward the nozzle *a*. The blast, therefore, in rushing past the mouth *g* in the direction indicated by the arrow *h*, tends to suck the saltpeter through the pipe *e*, and the blast carries the powdered saltpeter into contact with the metal at the points of combustion, or smelting portions of the metal, wherever the blast itself goes in contact with the molten and melting metal and fire, and with their oxygen, thus supplied, consume the sulphur and carbon and combustible matter, and purify the iron, giving it, or causing it to possess, great purity and strength. The saltpeter may be fed into the pipe *e* by a shoe and hopper, or a screw, or any other device.

When the saltpeter is fed into the blast at the eye of the blower, the pipe *e* should be set with its mouth *g* presented to the eye of the blower, the body of the pipe *e* extending upward above the eye, to near the top of the case of the blower, and a shoe or shaker is placed above it, to shake in the saltpeter from a hopper above the shoe. This forms an equivalent mode of combining the pipe *e* with the tuyere, so that the blast shall suck in and carry the saltpeter through the tuyere into the furnace, as before alluded to in this specification.

In casting ordnance, I recommend a repeated smelting of the pig-iron or iron by this process, before running it into the mold, and also I recommend the use of charcoal for fuel. The iron should be smelted twice before the final smelting, each time running it into bars or pigs and letting it cool, and using about twenty-five pounds of refined saltpeter to each thousand pounds of pig metal. After the second smelting, it can be stored away for use when needed. On the final smelting for casting into the gun, fifty pounds of refined pulverized saltpeter may be used to each thousand pounds of iron. The last smelting for ordnance may be with charcoal fuel alone, without the application of the saltpeter. Refined saltpeter is far better than crude, though I do not limit myself as to the quality of the saltpeter, in respect to the principle of my invention.

In this invention I do not mean to limit myself to any particular means or method of feeding the pulverized saltpeter to the tuyere, and it may also be supplied through a separate blow-pipe or supplemental tuyere, but not so advantageously.

I do not mean to limit myself to the use of any particular proportion of saltpeter at each or any smelting, nor to any certain number of smeltings of the iron. The quantity of saltpeter may be greater or lesser than I have named, and the number of smeltings may be greater or lesser. They are all contemplated by me, and are each and all within the scope and intention of my invention, as here specified.

The pulverized saltpeter, on this principle, may be supplied, also, in the smelting of the ores of gold, silver, copper, or other metalliferous ores, they all being comprehended within my invention and application of the pulverized saltpeter, by means of or with the blast, as here specified and claimed, or intended so to be. By this means the oxygen supplied and developed is brought in contact with every particle of the metal and combustible matter, and the most uniform purification and separation of the metal from all sulphur and earthy matter is effected.

Refined saltpeter is the best to use, as pure as possible, and I recommend it, and it should be pulverized very fine previous to use in this smelting operation. Any suitable flux may be used, limestone or other,

and I contemplate using it in connection with my flux of sulphate of baryta, patented by me May 4, 1869. It may be also used in the ordinary smelting-cupola, without a flux.

I am aware that oxygen salts have been converted into gas, and forced into a molten mass of metal below and into its surface, to purify the mass after it was smelted, and I do not claim any construction to carry on this process. Such process is impracticable to purify a large mass of fused metal and still have it in proper condition or degree of fusion to cast large bodies to be very strong.

With my process of purifying the metal when detaching itself in small particles at the point of fusion, the metal, when settled in mass or in the bottom chamber of the furnace, can be accumulated in large body and cast when at the proper heat or state of fusion to make a strong casting, which state of fusion experienced founders well know on sight of the fluid metal.

Also, my process produces a more thorough combustion of the sulphurous and carbonaceous matter of the fuel and metal, by uniting the oxygen immediately with it and the metal in particles, together at the fusion-point.

Having now fully described the leading features or principle of my invention,

What I claim is—

1. The supply of the pulverized niter, with and by means of atmospheric air, above the molten mass of iron, at the point or place of fusion of the metal, by means of the feed-tube or shoe *e*, connected to the ordinary blast tuyere of the furnace, or its equivalent shoe or tube at the eye of the fan-blower, substantially as described.

2. Also, the smelting of the iron repeatedly or successively, by this same process before claimed, so as to be able to accumulate it, in a purified condition, to make very large castings stronger and more pure, as described.

WM. W. HUBBELL.

Witnesses:
JAS. G. SMITH,
GEORGE OVERTON.

UNITED STATES PATENT OFFICE.

William Wheeler Hubbell, of Philadelphia, Pennsylvania. Improvement in breech-loading ordnance.

Specification forming part of Letters Patent No. 149,478, dated April 7, 1874; application filed March 18, 1874.

To all whom it may concern:

Be it known that I, William Wheeler Hubbell, of the city of Philadelphia, State of Pennsylvania, have invented a breech-loading cannon, of which the following is a specification:

The object of my invention is to load at the breech, for all sizes of cannon, with serge-bag cartridge and elongated projectile, and secure it tightly to fire, and open the breech freely to load, conform to expansion and contraction, and produce a durable serviceable gun by the peculiar construction of a circular breech-block, and of the breech of the barrel, with their appliances, to operate together as described, and shown in the accompanying drawings.

Figure 1 is a section through the axis of the entire cannon. Fig. 2 is a cross-section of Fig. 1 on the line *v*. Fig. 3 is a view of the front face of the circular breech-block. Fig. 4 is a front view of the face of the screw breech-piece *f*. Fig. 5 is a cross-section of the barrel of Fig. 1 on the line *w*, showing the front of the rear or breech when made of solid metal in place of the screw-breech *f*. Fig. 6 is a view of the lower face of the breech of the gun, with the circular breech-block *e* within the recess *y*.

Like letters refer to similar parts.

a a is the barrel, with rifled bore *d*, touch-hole *b*, and chamber *c*, to receive the projectile and serge-bag cartridge. *j* is a circular ring or bush, of square bar steel, iron, or copper, to form a joint or face for the rear face of the chamber *c*, against which the front face of the circular breech-block is tightly borne to form a close joint. *k* is the breech end of the barrel, and into it is firmly fitted a screw breech-piece, *f*, having a loading-hole, *g*, through it on a line with the chamber *c*, and fully as large in diameter. Below this loading-hole *g* is a shaft, *i*, extending parallel with the axis of the bore, and through the breech-screw *f*, which sustains the circular breech-block *e*. This breech-block moves backward and forward on this shaft, and half-way around and back with it, when squared, as shown, or on it when made round through the wheel. The breech *k* contains a mortise upward from the under side, as shown in Figs. 1, 2, 5, and 6, letter *y*. The mortise is open at the bottom. The sides are parallel and the top semi-circular, having a strong body of solid metal at the sides and top to connect the breech *k* with the barrel *a*, and endure the recoil stress of the discharge. The width of this recess is about equal to the diameter of the bore, and is made to receive the circular breech-block, of sufficient thickness and diameter for the size of the gun. The front face of the breech-screw *f* forms the rear face of the recess against which the circular breech-block bears. In Fig. 5 this face is shown in the solid metal of the breech. It is made either or both ways, and always has the loading-hole *g* and shaft-hole *i* through it, and also has the face formed with an inclined circular bevel from the line or face *r* to *u* and *t*. The face is about a quarter of an inch highest at *r*, and bevels across the loading-hole *g* to *u* in a half-circle, which forms the face on which the recoil stress is received from the circular breech-block. The bevel from *t* to *u* is to tighten firm upon as the breech-block moves up to inclose the charge. The bevel may extend from *t* to *s*; or this part may be level, leaving *r* the highest face, and extending horizontally, so that the resisting bevel-face is about equal both sides of the charge, or charging-hole, or bore of the gun. The breech-block is constructed of a diameter about twice and a half that of the chamber *c*, so as to admit the loading-hole *g*, the shaft *i*, and the inclosing-face *o* within its circuit. The front face *o*, Fig. 3, of this breech-block is at right angles to the axis of its shaft *i* and the axis of the chamber *c*, and the solid part *o*, Fig. 3, bears against the bush-ring or joint *j* of the chamber to inclose the charge to fire; and, by turning this breech-block half-way on its shaft, or with it, it presents the loading-hole *h*, opposite the chamber, to sponge out, and insert a new charge through the hole *g* in the breech, through the hole *h* in the block, into the chamber c, which are then coincident, and form a continuous channel for the passage of the charge forward in loading. The rear face of this breech-block is shown in Fig. 2. This rear face is also constructed with a circular bevel, the reverse of that on the breech-screw *f*, or breech-face *r u t s*, Fig. 5, and fits it firmly on the upper semicircle *r u* when tightened up. The letter *p* de-

notes the highest part of the bevel-face, and *q* the lowest part. The line between them is the shoulder between the top and bottom of this circular inclined plane or bevel-face. In making a half-turn, therefore, of this breech-block against the beveled breech-face the wheel is forced forward on its shaft against the joint *j* of the chamber and tightly incloses the charge; and reversing the breech-block half a turn releases this bearing and brings the loading-hole *h* in line, to insert another charge. The front face *o* of the circular breech-block, being wide, allows it to tighten up or turn more or less than half-way, to firmly secure the charge with a tight joint, as the contraction or expansion from cold or heat, or the accumulation of refuse matter, may require, it being self-regulating in this respect, owing to this construction, which is vitally important to the success of the gun. In order to turn or move and control this breech-block, cog-teeth *m m*, Fig. 2, are cut on the rear face of its periphery, a little over half the circuit, as shown, into which is geared a pinion-wheel, *n*, on a shaft with crank, *z*, secured to the lower face of the breech *k*, as shown in Fig. 6, the pinion-wheel *n* being shown in position also in Fig. 2. In case this pinion or crank gets broken I have made the main shaft *i* of the breech-block with a square, and to project in the rear to receive a crank, and thus turn it directly with this main shaft. The shaft is movable, and secured in place with a slot and pin, or catch. By removing this shaft the breech-block will fall out of the recess *y*. To place the block, it is raised up into this recess and the shaft slid into it at *i*. To stop the hole *h* opposite the chamber, a slot with shoulder *l* is cut in the periphery of the breech-block, Fig. 6, half-way around, into which drops a pin, *x*, Fig. 5, extending through and above the barrel. One shoulder, *l*, coming against this pin, stops the wheel when the hole *h* is opposite the chamber *c*; and when reversed the end of this pin comes against the opposite end or shoulder of this slot *l*, and by striking the pin it delivers a blow on the periphery of the breech-block, to start it in case it sticks in large guns, which may at times be possible. The breech *k* of the barrel is enlarged in diameter, as shown in Figs. 1, 2, 6, in order to make the recess *y* large enough to receive the circular breech-block and give a thickness of solid metal at the top and sides of the recess, to sustain the enormous recoil stress thrown on it. This thickness should be at least equal to and may be greater than the diameter of the chamber *c*. The breech-block should be made of steel or good iron, and its thickness about equal to the diameter of the chamber *c*. The breech-block may be cut across to form a loading-hole. In large ordnance I extend the grooves and lands back through the chamber *c*, through the loading-hole *h*, and through the hole *g* in the breech to the rear, and groove the projectile correspondingly, so that it takes the lands and the grooves on insertion, and passes forward into the chamber *c*, a rod, with shoulder, being used to regulate the distance of insertion. The projectile is loaded first, then the cartridge. In small or three-inch artillery, the projectile is banded with soft metal and canvass, or otherwise suitable material, and is pressed forward by the discharge from the smooth chamber into the grooves; or these small guns also may have the grooves and lands cut through to the rear and use a grooved projectile. In fact, both large and small guns may be grooved and used either way, this being one of the great advantages of this breech-loading system.

I claim as my invention—

1. The circular breech-block *e*, provided with bevel-face *p q*, and hung upon shaft *i*, in combination with the breech of the barrel *a*, having

bevel-face *r s*, the parts being constructed and adapted to operate together substantially as described.

2. The pin *x* operating through the barrel *a* in the slot *l*, to stop and start the breech-block, as described.

WM. WHEELER HUBBELL.

Witnesses:
JOHN SHAW.
S. A. MILLS.

(Filed with the Select Committee on Heavy Ordnance, United States Senate, Forty-seventh Congress by William Wheeler Hubbell.)

GUNS AND STEEL ARMOR—THE 100-TON ARMSTRONG GUN.

[From the London Times.]

The year 1882 will be remarkable in the history of artillery science, because for the first time steel and compound armor have come into competition with guns of the highest caliber and have shown their power of resisting any but almost fabulous blows. At the same time a gun has been produced capable of dealing such extraordinary blows, while the whole process of loading and laying the piece can be carried out by a single hand, no stronger than that of a lady. England and France have vied with each other in constructing the plates. The breech-loading 100-ton gun is English. We shall presently attempt to give some idea of the method of working the Armstrong 100-ton breech-loader, some of the features of which are quite new in the history of artillery. But before doing so it should be noticed that the total abolition of trunnions has so narrowed the space occupied by each gun that two of them can be easily and comfortably worked in a turret if necessary, though the present arrangements designed for the Italia and Lepanto are intended to fire *en barbette* from behind a breastwork. The Germans being confronted with the difficulty occasioned by the width of guns, have solved it by placing only one gun in each turret. Mr. Rendel, formerly of the firm of Sir W. Armstrong, and now at the Admiralty, has solved the same problem by his designs for the mounting of the 100-ton breech-loader. Instead of throwing away a gun, he has narrowed the space it occupies and placed the whole of the loading and laying arrangements safely out of the way, so that there is plenty of room in a turret for two guns if necessary.

The 100-ton breech-loading gun is composed for more than half its weight of steel, the rest being wrought iron. The inner tube and the nest tube which embraces it are both of steel, and on the exterior of the gun are rings of the same material. It is by far the strongest piece of ordnance ever constructed by the Elswick firm. Its principal dimensions are as follows: Length over all, 468 inches; length of bore (26 calibers), 442 inches; length of rifling, 335.4 inches; diameter at muzzle, 33.3 inches; diameter at breech, 65.5 inches; diameter of bore, 17 inches; diameter of powder chamber, 19.5 inches.

One of the most interesting points with regard to the gun is the method of mounting it. The usual trunnions are entirely absent. The gun lies imbedded on a sort of sledge carriage, which is a mass of steel, weighing about fourteen tons. Projecting rings, which form part of the gun, rest in grooves, and prevent only backward or forward motion of the piece on the carriage, and rotary motion is prevented by strong steel straps. Thus the gun and carriage are securely bound together, having their axes parallel, and recoil together in the same direction. The carriage rests and slides upon the planed surface of two cast-steel beams of about ten tons weight each. They are held together by the recoil press, and their front ends pivot vertically on a massive hinge. Thus the axes of the gun, the carriage, the recoil press, and the slide are all parallel, whatever the elevation, and the difficulty of restraining the rotary motion caused in other systems by recoil is completely got rid of. The whole weight is taken by two powerful hydraulic presses, which work always together, being acted upon by one common supply pipe. If the muzzle of the gun is to be elevated the hydraulic rams sink, and the slide, pivoting on its front end, is lowered in the rear, carrying with it recoil press, gun and carriage. The reverse takes place when the gun is to be depressed. By this simple arrangement a host of difficulties are at once eliminated, and some terrible strains removed from the system. And not only is there

the advantage of harmonious recoil, but the pivoting on the end of the slide enables the gun to be fired through a very small port, which it would fill almost completely. This is an improvement on the Inflexible, where it has been found necessary to attach to the muzzle of the gun a steel shield, formed of two-inch bars, to guard the port from the fire of rifles and machine guns.

The loading arrangements are also extremely simple, and present some features of novelty besides the mere fact that the gun is loaded at the breech. With the exception of bringing up the ammunition and ramming, which are performed by another hydraulic apparatus, the whole business of opening and closing the breech is performed by two levers close together, which are worked by one man. He cannot make a mistake, for nothing can be moved out of its proper order, and whatever position a lever may be in at the end of its last movement, the next act is performed merely by pushing or pulling the lever to the opposite side. One pair of levers works the whole breech-closing apparatus, prepares the gun for loading, or opens the breech after discharge. Another pair of levers runs the gun out and in, and elevates or depresses it. It is impossible to run it back or forward too far, and the whole mighty mass of metal may be managed by the hand of a lady, who cannot possibly make a mistake. If she touches a lever it must be to pull it back or thrust it forward from the position in which it then lies, and no movement that can be made will set anything wrong. All the movements involved in opening the breech, withdrawing the breech-screw, replacing and closing the breech, can be performed in less than one minute. No damage can be done in the heat of action, and the gun cannot be fired till the operation of loading and closing the breech has been completely performed. The whole process seems like magic, so simple is it, so easy, and so certain. The most inexperienced person can learn the movements in five minutes.

It is almost impossible to make the process of loading and laying the gun understood without the aid of drawings, but some idea of it may perhaps be given to those who have a knowledge of mechanics as applied to artillery. The hydraulic pumps are worked by a small steam-engine, which is governed in its rate of work by the pressure of water produced. It never ceases work, but when no movement is required of any of the parts its action is feeble and only keeps up a certain normal pressure. But if any motion of the system is required and the touch of a lever opens the way for water to create that motion, the engine instantly sets off briskly and continues to act till the cessation of movement tells it that its services are no longer required. It then drops back at once to its slow and feeble action. The engine is seated on a tank, from which the pumps draw their water, and to which the water is returned after being exhausted from the various cylinders and pipes. Behind and across the breech of the gun, but entirely separate from it, is a slide-bed similar to that of a lathe, and on this bed moves a saddle which carries the loading-tube and a rest for the breech-screw when drawn out of the gun. Now, let us suppose that the gun has been fired and requires to be loaded. By touching the levers for elevating and running back, the gun is brought into the loading position exactly. It cannot go too far in either direction. A touch on another lever brings the saddle into its proper position, unlocking and turning the breech screw as it comes. A touch on the third lever brings up a piston from the rear and makes it engage a catch in the breech screw. The same lever moved in the opposite direction draws out the breech screw upon a bed made to receive it on the saddle, which is then drawn out of the way by a reverse movement of the lever which brought it. As the saddle moves sideways, that part of it containing the loading-tube comes into position exactly behind the rear end of the bore. The small piston which withdrew the breech screw now pushes the loading tube into the gun, the object of the tube being to protect the threads of the female breech screw from abrasion by the shot. All is now ready for loading, which is performed as in the muzzle-loading 100-ton gun. The projectile and its two half-charges are always kept ready on trolleys, which rise by hydraulic pressure from their places in the magazines, and arrive between the hydraulic rammer head and the breech of the gun. Other levers thrust them forward into their places; the loading tube is withdrawn and the breech closed by a reversal of the different movements just decribed, which do their work more quickly than the description of their action can be read. The breech of the gun cannot be moved till all is complete, and the piece cannot be fired unless the breech is accurately closed and locked to prevent its opening.

When mounted in the Italia and Lepanto, for which they have been designed, these 100-ton breech-loaders will be *en barbette*—that is, they will be elevated so as to see over the top of the battery as in the French ships, but there will be this advantage, that whereas in French men-of-war the men working the gun are exposed to the fire of small-arms, machine guns, and shrapnel, not a single man will be exposed in the Italian ships. The whole of the machinery, which, though elaborate to describe, is simple and massive in reality, will be under an armored deck. The only break in protection by the deck is the portion through which the rear part of the gun descends, and that will be covered by the mass of metal composing the gun. In the French ships,

gun and gunners are equally exposed. It needs no technical knowledge to understand how valuable this advantage is.

Number of rounds.	Powder charge.		Projectile weight.	Velocity in feet per second.	Pressure in bore of gun in foot-tons per square inch.
	Weight.	Description.			
1	496	Fossano		1,433	10.9
2	551.2	....do		1,496	11
3	551.2	....do	Chilled, 1,974	1,512	11
4	606.3	....do	Chilled, 1,942	1,593	11.35
5	606.3	....do	Chilled, 200.1	1,609	11
6	661.4	.. do	Chilled, 2,005	1,676	12.5
7	661.4	....do	Chilled, 2,005	1,688	12.4
8	716.5	.. do	Chilled, 2,005	1,767	13.6 14.1
9	771.6	....do	Chilled, 2,005	1,833	16.5
10	716.5	... do	Chilled, 2,005	1,761	14.5
11	496	Prismatic	Chilled, 2,005	1,423	9.3
12	551.2	....do	Chilled, 2,005	1,506	10.4 10.3
13	551.2	....do	Chilled, 2,005	Not taken.	11.6
14	771.6	Fossano	Chilled, 2,005	1,831	16.4
15	606.3	Prismatic	Chilled, 2,005	1,605	12.8 12.5
16	606.3	....do	Chilled, 2,005	Not taken.	13.5 13.6
17	716.5	Fossano	Chilled, 2,005	Not taken.	13.8 13.7
18	771.6	... do	Chilled, 2,005	Not taken.	15.9 16

Having now described the gun, the method of mounting, and the process of loading, it remains to tell what the piece has actually done, and to explain why such huge weapons are required for the ships of the future. The table shows the rounds recently fired at Spezia, but it should be remarked, first, that the strength of the gun is calculated to bear with safety a pressure of twenty-nine tons to the square inch, while the highest yet reached is 16.5 tons; secondly, that though the greatest charges ever yet fired in a gun have now been exceeded, the powder chamber has room for a much larger charge than any used at Spezia; and, lastly, that there is an evident intention on the part of the Italians to try even more powder, experimentally at any rate. Indeed, it is not improbable that they may, as they did with the muzzle-loading 100-ton gun, increase the charge until it passes the limits of safety, for the sake of experiment. Such a course would be interesting to scientific artillerists, but might damage the confidence of the Italian navy in its guns and the Italian people in their navy. It is also probable that the breech-loader will be fired at the Schneider steel plate, which is still untouched, and the question will be decided whether the solid nineteen inches of steel will resist the impact of a projectile which has a total energy of about 46,000 foot-tons.

With regard to the preceding table it is to be remarked that both Fossano (Italian) powder and prismatic (German) powder were provided for the experiment, but, finding that there was little to choose between them, the committee decided to adhere to their own explosive. Rounds 13, 16, and 18 were fired with almost the full elevation possible—namely, 11° 50′—and therefore did not register their full velocity, because they passed over the screens instead of through them. The range out to sea was evidently enormous, but formed no part of the test trial, and was therefore not measured. The shot was 184 seconds in the air before touching the water. Round 17 was fired with almost full depression—namely, 3° 59′—and plunged into the sea below the screens, throwing up a magnificent column of water about 100 feet high.

The results of these experiments have shown that guns weighing 100 tons can be manipulated with greater ease by means of hydraulic power than the 12-ton 9-inch gun without it. The whole apparatus takes up very little room, and is perfectly simple in character. There is no reason why a gun of 150 or 200 tons should not be manipulated with equal ease. If it be asked why such monstrous pieces of ordnance should be used at all, the reply is that the condition of the controversy between guns and armor plates has been completely changed by the construction of steel and compound armor.

It has now become necessary to give up the idea of perforating the armor of the future with anything less than such a piece as the 100-ton breech-loader, and the power of guns against armor must now be estimated by the total energy of the blow delivered instead of by the old calculation of the energy per inch of shot circumference. In the days previous to the trial of the big breech-loader, the muzzle-loading 100-ton gun was fired at two English compound plates nineteen inches thick—one made by Cammell and the other by Brown, and at a Schneider steel plate. The English plates were not sufficiently bolted to the backing, and therefore came to pieces more easily than they ought to have done. Moreover, from want of machinery designed to roll such very thick plates, they had not been worked down so much as they should have been and will be in the future. The first round fired at each plate was with a charge of 328.5 pounds of Fossano powder, less than half the highest charge fired from the breech-loader. The striking velocity was in each case about 1,220 feet, and the total weight a little above or below 20,200 foot-tons. In no case was the plate perforated, nor did any serious injury occur to the backing, though the shot would have gone clear through a 19-inch wrought-iron plate. A second round was fired at each plate with a charge of 478.4 pounds of Fossano powder, giving a striking velocity of 1,560 feet approximately, and a total energy of about 33,900 foot-tons. These rounds would have pierced a 25-inch wrought-iron plate, yet they failed to perforate any of the three pieces of armor opposed to them, though the steel plate was cracked badly and the two compound plates were broken to pieces.

In all three cases the backing suffered, but less in the case of the steel plate than of the others. Against the Schneider steel plate was now fired a Whitworth steel projectile, with a striking velocity of 1,538 feet and a total energy of rather more than 34,000 foot-tons. The plate was broken up and the backing dashed in by the total force of the blow, though the shot itself had been rejected, and lay, defaced and distorted, among the *débris* at the foot of the front of the target. At these experiments were present experts from the principal nations of Europe, and among them all there was but one opinion, namely, that the object of the artillerist in designing ships' guns for the future must be to endeavor to gain, by means of large calibers and enormous projectiles, the greatest possible total energy of blow. Plates of such quality as those tried at Spezia cannot be pierced, or, indeed, destroyed in any way, by projectiles from moderate-sized guns. The side of the ship must be driven in by the single blow of a huge projectile delivered from a monstrous piece of ordnance. This is what the future seems to have in store for us, and it can hardly be said that the prospect is satisfactory. It is necessary to correct a statement which appears to have got abroad that in the experiments against the steel and compound plates the 100-ton breech-loader was used. Not so—the gun was the 100-ton muzzle-loader; but it was generally understood at Spezia that the breech-loader will before long be fired at a new 19-inch Schneider plate, which is already on the practice ground.

JANUARY 13, 1883.

MR. W. W. HUBBELL'S PROPOSITION.

Mr. HUBBELL completed his proposition by filing a model of the gun proposed by him.

STATEMENT OF H. F. MANN.

Mr. H. F. MANN, of Pittsburgh, Pa. Mr. Chairman, under the act of Congress approved March 3, 1881, a Board of Officers was convened—

To make examinations of all inventions of heavy ordnance and improvements of heavy ordnance and projectiles that may be presented to them, including guns now being constructed or converted under direction of the Ordnance Bureau; and said Board shall make detailed report to the Secretary of War, for transmission to Congress, of such examination, with recommendation as to what inventions are worthy of actual test, and the estimated cost of such test.

Being the inventor of valuable improvements in breech-loading rifled ordnance, and projectiles for breech-loading rifled ordnance, I submitted to that Board, by model, drawings, arguments, and records, my said improvements, respectfully requesting its favorable consideration and action.

The report of the Board—known as the Getty Board—was transmitted to Congress by the honorable Secretary of War, under date May 29, 1882.

By that report I learned that the Board had refused to recommend my system of breech-loading rifled ordnance as being worthy of actual

test, and assigning certain reasons for its refusal, which reasons I considered were not warranted by any statement made by me, or any fact presented, or any information that is within the knowledge or experience of the Board. Believing, therefore, that the Board had done me very great wrong and injustice, I immediately submitted to both houses of Congress a memorial protesting against the action of the Board. Said memorial and protest reads as follows:

To the Senate and House of Representatives of the United States in Congress assembled:

I respectfully represent that I am a citizen of the United States; that I am the inventor of a system of breech-loading ordnance which I verily believe possesses superior merits as to simplicity of construction, strength, durability, and facility for easy loading and rapidity of fire, and that if properly tested would demonstrate its great value to the government either for field service or coast defense.

I would further state that I submitted my system of breech-loading rifled ordnance and projectiles for rifled ordnance by model, drawings, descriptions, and argument to "The Board on Heavy Ordnance and Projectiles," appointed in pursuance of the act of Congress approved March 3, 1881, requesting its favorable consideration and recommendation of my system as being worthy of actual test.

That the said Board has reported the results of its examination and made recommendations, which report and recommendations were transmitted by the honorable Secretary of War to the Senate under date May 29, 1882.

[Extract from report of the Board.]

28. H. F. MANN'S PLAN FOR GUN CONSTRUCTION AND BREECH MECHANISM.—This gun consists of a cast-iron barrel, bound around the powder chamber by steel bands. It is 30 feet in length, weighs 92,000 pounds, and is balanced on its trunnions. The breech fermeture is held to the trunnions by heavy steel straps, the whole arrangement weighing 37,000 pounds additional to the weight of the barrel, giving a total weight of 129,000 pounds. This fermeture is the characteristic feature of the gun, and is the invention of Mr. Mann. The principal objection to it is its great weight, but further, it necessitates the turning of the barrel of the gun on its trunnions through an arc of about ten degrees and back again at each discharge, requiring the expenditure of more time and force than for either the Krupp wedge or the slotted screw system. The piece possesses no advantages over the cast-iron gun bound with steel bands and with the screw fermeture, recommended by this Board for trial, unless it be that it gives greater security against transverse rupture. Trials, however, of guns of similar construction, but with the simple screw fermeture, have proved successful with moderate limits of powder pressure—all that is claimed for the design of Mr. Mann, as is evidenced by his powder charge and weight of projectile. The only apparent merit of the structure consists in relieving the body of the gun from longitudinal strains, and transferring them through the detached breech by means of steel straps to the trunnions. But in view of the objections, set forth above, to the fermeture itself—the specialty of Mr. Mann's invention—this Board fails to see sufficient reasons for recommending the gun for construction and trial.

That your memorialist learns from said report that the Board refused to recommend that a breech-loading gun upon my system be constructed for trial by the government, and assigning certain reasons for its action, some of which reasons your memorialist verily believes do me very great wrong and injustice, and are not warranted by any statement made by me to the Board, or by any fact presented, or any information that is within the knowledge or experience of the Board.

1st. The Board charges me with presenting for its consideration a "plan for gun construction and breech mechanism." Referring to its report, it says: "28. H. F. Mann's plan for gun construction and breech

mechanism," and proceeds to discuss the construction of the barrel of my breech-loading system, which was not submitted by me as a "plan of gun construction," but was shown only as a means of embodying my system of breech-loading. This was so stated in distinct terms by Prof. R. H. Thurston in his argument in presenting my system to the Board. His statement was as follows:

The method of construction of gun-barrel is one with which we are not specially concerned. This system, of course, adapts itself to any construction of gun-barrel, but in my own mind there is no question as to the propriety of constructing the barrel of the strongest, the most homogeneous, and at the same time toughest metal that we can make. If, however, we are restricted in cost, it becomes necessary to construct it of a cheaper metal; and if we have to construct it of a cheaper metal, we propose to use cast iron—*i. e.*, ordnance metal. The general plan of construction is that indicated on the drawings here presented.

To show further, if necessary, that I did not present any system of gun construction, but only a system of breech-loading, and proposing the use of any construction of gun-barrel that might be found to be reliable, the following from the record shows:

Comparing this gun with others, we think we have brought forward the simplest form of gun construction (meaning the breech-loading gun as a whole), the safest, the easiest to design, and a gun more quickly worked than any gun yet invented. The external reinforcement, we think, will give greater strength than the cast iron alone can have. Of course we prefer to make that barrel in the best metal, the best—which is also the most expensive—steel.

General TOWER. There is nothing particularly new in your barrel—the novelty lies in your manner of breech-loading system?

Mr. THURSTON. No; there is nothing peculiar in the barrel of the gun. What is claimed is the construction of a barrel, open at both ends, closed at the breech by means of mechanism independent of the barrel.

General TOWER (to Mr. Mann). Then you call yourself the inventor of that method?

Mr. MANN. I consider myself the inventor of that system of opening and closing the breech.

General TOWER. That is your point?

Mr. MANN. Yes; to provide for all directions of expansion and contraction of the metal. I do not claim any special point in the barrel itself, except the manner of putting the series of bands at the breech.

General TOWER. You cannot claim anything beyond your specific arrangement of pieces?

Mr. MANN. Nothing more than that. The form, as presented, is simply the form of gun designed, as the inventor would design it, to embody his invention. * * * We introduce no new material, but can utilize any material that may be brought forward as being the best.

I protest, therefore, that the Board does me great injustice in considering that I presented to it a plan of gun construction, and makes that one of the reasons for rejecting my system of breech-loading—at the same time the Board well knowing that the construction of barrel presented by me as a means of embodying my invention and system of breech-loading is substantially similar to those of guns that have heretofore given good practical results under tests of service, and is also substantially similar to the 12-inch breech-loading guns recommended for test, but upon a different system of breech-loading. As a gun construction, so far as the barrel is concerned, we propose to use what is known to be the best, *when that question is decided;* and it was so stated distinctly and repeatedly. *I can use steel, wire wound, or any construction of barrel that is known, by actual test, to be most reliable.*

2d. The Board objects to my gun on account of "its great weight," and designates as a "fermeture" a large portion of my gun proper. I contend that, as "fermetures" applied to the "Krupp wedge" and the "slotted" or "interrupted screw," my system of breech-loading has no "fermeture."

The total weight of my 12-inch breech-loading rifled gun is stated as being 129,000 pounds, and the bore "30 feet in length," or 30 calibers.

One of the two 12-inch breech-loading rifles, on the interrupted screw system, recommended by the Board, weighs 127,284 pounds for 26 calibers, or 26 feet in length of bore; and the other 126,298 pounds, of the same length—26 calibers. If the 12-inch breech-loader proposed by me is reduced to the same length of bore—26 calibers or 26 feet—as those recommended by the Board, it would be from 2,500 to 3,500 pounds less in weight.

3d. The Board states that "it necessitates the turning of the barrel of the gun on its trunnion, through an arc of about ten degrees, and back again at each discharge, requiring the expenditure of more time and force than for either the Krupp wedge or the slotted screw systems." This statement of the Board, I protest, is not warranted by any statement made by me; that no gun has ever been made or tried upon the plan I proposed; that there is no produced fact or theoretical rule that warrants such a conclusion. Upon the contrary, the records of the Ordnance Department show that in actual practice it frequently requires two men to open and close the breech of an 8-inch gun, in which the Krupp wedge is used, and it is safe to say that the same is true of the slotted screw system. While a theoretical calculation shows that a man with one hand would open and close the breech of a 12-inch gun constructed upon my system, I assert that a gun constructed upon my system of breech-loading can be loaded, fired, and reloaded in half the time required for the Krupp wedge or interrupted screw system.

4th. The Board admits that my gun "gives greater security against transverse rupture." This is one of the points I claimed for my system, and is one of the most important questions connected with the ordnance problem; guns, both breech and muzzle loading, are constantly failing, under proof and in service, by transverse rupture, as witness the failure by transverse rupture of the Woodbridge gun at the 93d round while under test by the Board; and the failure by transverse rupture of an 8-inch Crispin breech-loader at the 3d round, and an 11-inch at the 18th round, and another 8-inch at the 127th round. Numerous other instances of the failure of guns could be cited from the records, showing the great difficulty of providing sufficient longitudinal strength in a gun to prevent transverse rupture.

The Board say further in regard to my system of breech-loading:

> The only apparent merit of the structure consists in relieving the body of the gun from longitudinal strains and transferring them through the detached breech by means of steel straps to the trunnions.

This is very important; one of the greatest difficulties in the solution of the ordnance problem has been to provide sufficient longitudinal strength to prevent transverse rupture.

The Board, in its report, admits that my system of breech-loading "gives greater security against transverse rupture;" that I relieve the body of the gun from longitudinal strains, and transferring them through the detached breech by means of steel straps to the trunnions."

If, upon fair trial of my system of breech-loading guns, the admissions of the Board, as stated in its report, should prove true, I believe that the solution of the ordnance problem is a comparatively easy one, and that we can secure, within the limits of our own resources, a safe, reliable, and durable breech-loading rifled gun.

Having a large practical experience and some theoretical knowledge of the character, capacity, and strength of materials, and having given the subject of ordnance, as to its material and structure, much consid-

eration, I feel warranted in saying that the Board has failed to comprehend the advantages of my system of breech-loading ordnance, and I respectfully ask for its consideration by Congress.

All of which is respectfully submitted.

H. F. MANN.

PITTSBURGH, PA., *June* 7, 1882.

The Senate, at its last session, instead of approving the report of the Getty Board, deemed it proper to appoint this joint Select Committee, to take into consideration the subject of heavy ordnance and projectiles, and make such recommendations as the committee might deem proper.

Therefore, Mr. Chairman, I will try to discuss, in my crude way, the subject of heavy ordnance, and to describe and illustrate, by models, drawings, and records, the superior merits of my system and improvements in breech-loading ordnance, and the inconsistency of the report of the Board. And if in this connection I should say anything that seems to reflect upon the official honesty or unfairness of the Ordnance Department of the Army or any of its officers, I assure you I will keep within the records and facts.

The CHAIRMAN. Before you proceed to the illustration, let me ask why do you insist on a gun of that weight and length?

Mr. MANN. I do not insist upon it. I am not confined to weight or length any more than any other system or construction of guns.

The CHAIRMAN. I thought it was said that the objection made to it was as to the length and the weight of the gun.

Mr. MANN. The Board made that objection, and I make that comparison to show that the Board were in error and did me great injustice in considering my gun objectionable on account of its weight, because the gun as I propose weighs less than those they recommended. I only refer to that for the reason that the Board makes that as one of its objections to my gun on account of its weight, when the weight for the same caliber and length of bore is less than that of the guns recommended by the Board.

This fermeture is the characteristic feature of the gun, and is the invention of Mr. Mann.

They accuse me of bringing forward a 12-inch breech-loading gun, having a fermeture weighing 37,000 pounds, when in fact this 37,000 pounds is a part of the gun proper. The fermeture, if it has one at all, is a cup-shaped disk, which is inserted in the rear end of the barrel or chamber, and would not weigh more than four or five pounds for a 12-inch gun.

The CHAIRMAN. They used in that, I suppose, the fermeture of these steel straps that run from the trunnion back.

Mr. MANN. They call that part of my gun, the parts that make up the gun (indicating the side straps, breech block, transom and screw), the fermeture of the gun. I say it is utterly inconsistent to put it in that way. The fermeture is that little piece (indicating small cup-shaped disc) that is put into the rear end of the bore or chamber.

The CHAIRMAN. How much does that attachment called the fermeture, including the straps, weigh—that connected with the trunnions to hold the fermeture steadily in place when the shell is out?

Mr. MANN. Let me get, if possible, that question properly understood. These side straps, transom, and breech-block, and all as arranged here, weigh, for a 12-inch gun of 30 calibers or 30 feet length of bore, about 37,000 pounds.

The CHAIRMAN. That is what they mean then, I presume?

Mr. MANN. Yes; but I say that they do me injustice in calling it the fermeture, and objecting to it because of its weight. The fermeture, as applied to the Krupp wedge system, and the slotted screw system in my gun, would weigh only four or five pounds. It is simply a little cup that is inserted in the rear end of the bore or chamber.

The CHAIRMAN. What you describe is the part that goes into the gun and presses up against the shell?

Mr. MANN. Yes, sir; or rather against the powder charge that closes the joint between the junction of the bore and breech-block. That is the fermeture to my gun, if it has one.

The CHAIRMAN. They may have included more. Now, you say you include the straps that connect with the trunnions and hold fast the fermeture there, and all that apparatus taken together does weigh 37,000 pounds?

Mr. MANN. Yes, sir; that is the estimate made of the weight.

The CHAIRMAN. Now, what will the gun weigh?

Mr. MANN. The gun or barrel, I presume you refer to, is estimated to weigh 92,000 pounds.

The CHAIRMAN. That is, the gun weighing 92,000 pounds, and all the other apparatus connected with it weighing 37,000 pounds, the whole would be 129,000 pounds?

Mr. MANN. Yes, sir; that is a correct statement of the estimated weight of the gun, but the side straps and other arrangements here are part of my gun as a whole. It is not a fermeture, but the parts that furnish longitudinal strength to the gun, and gives, as the Board admits, "greater security against transverse rupture."

The CHAIRMAN. I understand; but it makes the whole gun weigh 129,000 pounds.

Mr. MANN. Yes, sir; and it is a lighter gun than two of the guns they recommended by several thousand pounds.

The CHAIRMAN. My idea is to get at what makes up the weight.

Mr. MANN. But you see, Mr. Chairman, the point I make is that parts of my gun proper is called by the Board the fermeture, and they object to it on that account. It would not be a Mann breech-loading gun without these side straps and arrangements that make up the complete gun.

The CHAIRMAN. It would not last very long, I should think.

Mr. MANN. It would not last very long, neither would it then represent my system of breech loading. Here is a model of a breech-loading gun with the slotted screw fermeture [exhibiting] model, and here is the illustration of one of the systems presented to the board by the Chief of Ordnance (referring to drawings of a breech-loading gun on the slotted screw system, having a cast-iron barrel banded with steel bands and weighing 127,284 pounds). Here is the Krupp system, with the wedge fermeture [exhibiting model].

The CHAIRMAN. That is the Krupp gun?

Mr. MANN. Yes, sir.

The CHAIRMAN. How long is it since that has been invented?

Mr. MANN. That is a pretty difficult question to answer. A recent number of The Engineer gives an illustration of a beautiful breech-loading bronze gun, showing the wedge formation for closing the bore, made in 1650. Piobert, in 1845, gives a description and illustration of a breech-loading gun having a wedge formation for closing the breech, and gives 1439 as the date when it was made or invented.

Another point the Board makes against my gun is that—

The principal objection to it is its great weight, but further, it necessitates the turning of the barrel of the gun on its trunnions through an arc of about ten degrees and back again at each discharge, requiring the expenditure of more time and force than for either the Krupp, wedge, or the slotted-screw systems.

Now, in opening and closing this gun, a 12-inch gun, 30 feet long, or 30 calibers, the muzzle or extreme end of the gun moves in the arc of a circle about 36 inches. That does not seem to me to be very objectionable to a gun that is 30 calibers or 30 feet long. In opening and closing the breech the muzzle is moved about 36 inches downward, while the breech end of the barrel is raised about 15 to 18 inches, exposing the end of the bore—a chamber—so that it can be readily loaded without difficulty. We enter the shot and charge at once in the end of the gun. We do not have to pass it through 20 to 40 inches before we get them into the chamber, as is the case with the wedge or slotted-screw systems of breech-loading. They go immediately into the chamber.

Now, for the Krupp system, as illustrated here. If we fire at an angle of 10 degrees, more or less, we must tip the gun up so as to get the shot and charge in here (illustrating). We cannot very well load a breech-loading gun by having it at a considerable elevation, because of the great weight of the powder and shot that must be pushed up this inclined plane. In opening the breech of my gun, preparatory to loading, I put the inclined plane the other way. In loading guns with either Krupp, wedge, or slotted screw, you have to pass all these delicate breech-closing arrangements to get the shot and charge into the chamber. I put them directly in at the end of the bore. So it is with the other guns; you have to move them in the arc of a circle or load up an inclination. I have the advantage, because I move mine so that we load down hill, if you please.

The CHAIRMAN. Do they not do the other that way?

Mr. MANN. No, sir; if they move so that they load down-hill, as I do, they have to move their gun in the arc of a circle twice the distance I have at the same elevation. Do you see the point?

The CHAIRMAN. No, I do not see that point.

Mr. MANN. We will suppose that the gun is at 10 degrees elevation. Now, to load down-grade, as I do, they have got to pass the level and——

The CHAIRMAN. Suppose the gun is on a level?

Mr. MANN. Then they have to load on a level.

The CHAIRMAN. I do not say that they have, but they may do it.

Mr. MANN. Pardon me, they may do it. If it is at an elevation they must load up-hill, or bring it to a level or a depression. If my gun is at 10 degrees elevation I throw up the breech, and we load on a level without disturbing the elevation of the gun for firing.

The CHAIRMAN. That is the same principle precisely, because if this is on a level, or if it is at 10 degrees elevation and there is nothing to the rear of it, you can load on a level or turn it, and there is nothing to prevent the shell going in.

Mr. MANN. No. I am speaking of the Board's objection. I am not speaking of what is actually the fact as to the loading of the gun. I am speaking of the objection. The history of the loading of this gun, the Krupp—and the same is true as regards the Slatter screw system—the record shows that when they are firing these guns at an elevation, especially if at a considerable elevation, they must bring them to a level or to a depression in order to load them.

The CHAIRMAN. Yes, and I suppose they would have to do yours the same way.

Mr. MANN. No, sir. If my gun is at 10 degrees elevation it comes to a level when we open the barrel for loading. Suppose it is at 10 degrees elevation, when we throw the breech of the barrel up ready to load, the bore is on a level. If we are firing at what they call point-blank range, we give it a depression of 10 degrees, and it would be loaded down here [illustrating] instead of on a level; and we introduce the charge right at the end of the bow of the gun, instead of passing it through delicate breech closing arrangements, as is the case with the Krupp, wedge, and slotted screw systems.

The CHAIRMAN. Where a shell is swung by an apparatus, as it has to be with such an immense weight, what is the difference whether you load at an elevation or on a level?

Mr. MANN. There is quite a difference when you undertake to put your six or seven hundred-pound shot up an inclination or grade of 10 degrees, or whether you move it at a level, or down the inclination. Take any such gun as this, and your shot and charge have to pass this delicate slotted-screw arrangement or the Krupp-wedge arrangement, as illustrated here, and it makes quite a difference whether you put it in that direction or simply in the smooth surface, as in mine. Not only that, but before you load at all, you introduce a cylinder or trough into these guns to protect them. You have many more appliances to handle. I have nothing of that kind at all.

The Board says that to open and close the breech of my gun it requires the "expenditure of more time and force than for either the Krupp or slotted-screw systems." This I most emphatically deny. The Board has no practical knowledge on this question, as *there has never been a gun made upon the plans I submitted to them.* How, then, *can* they know? Theoretically, one man will open and close the breech of a 12-inch gun made upon the plan I submitted to the Board.

The records of the Ordnance Department show—they are here before me—that in operating an 8-inch gun made on the Crispin plan, with the Krupp wedge like this [exhibiting models and drawings], it frequently takes two men and the use of a crow-bar to open and close the gun, to move this wedge out and put it back again. In the 100-ton Italian gun, which is on the slotted-screw system, they have to move a breech screw that weighs nearly 2,000 pounds; they have to take out part of the gun, and swing it around, requiring the force of a four horse-power steam engine; you have to do that in addition to the weight of the shot, handling the shot, putting it through the slotted-screw arrangement. Shot weighing over 2,000 pounds has to be put across this slotted-screw arrangement, about 24 inches before you enter the rear end of the chamber. We enter the rear end of the chamber of my gun at once. There is no screw to pass; there are no delicate fixtures to pass. With the Krupp arrangement, you have to pass through that great length to reach the chamber.

Here is the drawing of the 12-inch Crispin gun, which shows that before you can enter the rear end of the chamber the projectile and powder must pass through a space of 38 inches. In my gun we do not pass an inch until we get to the rear end of the chamber; we are right there when the gun is opened. The Board objects to my gun for such reasons, which to my mind are simply absurd, and without any foundation in fact.

I will repeat the question of the amount of power to operate the gun. I stated that it frequently required two men, with a bar, to operate an 8-inch or 11-inch Crispin gun with the Krupp wedge; how many it would take to operate a 12-inch gun I do not know. Probably it would

take four or more, because the weight of the wedge increases enormously with the increase of the size of the gun. There never has been a gun made on my system with this arrangement for opening and closing the breech, so that the Board is entirely in error in stating that it requires more time and force than it does to operate the Krupp gun, or guns made on the slotted-screw system. A practical trial will fully demonstrate that a breech-loading gun constructed upon the plan proposed by me can be operated with *less force* and in *one-half the time* required to operate guns of the same caliber made on the Krupp-wedge or slotted-screw systems.

The CHAIRMAN. What gun did they adopt?

Mr. MANN. They have recommended for test 8 guns all on one system of breech loading.

The CHAIRMAN. What system is that?

Mr. MANN. The slotted-screw system. I will say in this connection that it is fair to suppose the Getty Board was organized to make examinations to see what tests should be made by the government in order to secure the best gun and the best system of guns for adoption by the government. How are we to determine what system is the best by making 8 guns all on one system? Should we not make and test guns on different systems in order to ascertain which is the best? And why should we make for test some of the guns recommended by the Board at all? The records are full of the history of these guns that the Board have recommended. The French and Italian system with the slotted-screw breech-closing arrangement submitted to the Board by General Benét, Chief of Ordnance, is a well-known and well-tried system, and in my judgment any further test of it by the United States would be a waste of time and money. The merits of the system have been settled. The French, Italian, and other governments have adopted it, and large numbers of guns have been made and put into service. Why come here and ask the Congress of the United States to appropriate money to go on and rehash those tests? Why not take the records of the tests of those guns in the French and Italian and other services? What we want is to try to get a better gun.

The records show that this has been known to the Ordnance Department for years. I desire to call the committee's attention to some of those records. Here is Naval Mission to Europe by Simpson, in 1870–'72, volume 2; illustrates and describes the system we are now considering. The Getty Board recommends for test two cast-iron guns on this French and Italian system of construction. The French use a cast-iron body with a steel lining tube, extending about half the length of the bore inside, and two sets of steel bands on the outside. The Italians use the cast-iron body with the two sets of steel bands on the outside, dispensing with the steel lining tube. That system has not heretofore been considered by the Ordnance Department as a proper thing to test. Why spend money to test those guns when the records show they have been, time and again?

The CHAIRMAN. Tested by the French and Italians?

Mr. MANN. Yes, sir.

The CHAIRMAN. Have they proved successful?

Mr. MANN. They have proved successful, so that they are in the service. Here is the illustration of a gun in Simpson's report [exhibiting an illustration of a 28.55 centimeter gun mounted]. There is another [exhibiting illustration of a 24 centimeter gun mounted]. There is the sectional drawings of it, the same as that [showing drawings] of the gun recommended by the Board. Can you see any difference? Also, see report of Chief of Ordnance for 1877, containing the report of Colonel

Laidley, Major Benton, and Major Crispin who, under War Department orders dated May 22, 1873, proceeded to England, France, Germany, Austria, and Russia "for the purpose of collecting information in regard to the construction of heavy cannon and other ordnance manufactures." In this report (page 540) we find a description of the Swedish breech-loader on the slotted-screw system and the "body of the gun is made of cast iron reinforced with steel rings." On page 541 a description of the French breech-loading gun is given, and illustrated by Figs. 60 and 61, showing the slotted-screw system applied to a gun having a cast-iron body banded and tubed with steel. So we see the Ordnance Department has been "alive" to the best interests of the government, and General Benét, Chief of Ordnance, in his report for 1876, page 10, says under the head of "breech-loading cannon":

The subject has, therefore, not escaped the attention of this department, and the Board on Experimental Guns, of date the 10th June, 1875, "recognizing breech-loading rifles for casemate service to be a great desideratum, believe that a portion of the appropriation should be expended in this direction," and recommended "that a sufficient sum be used for the conversion of two 10-inch smooth-bore Rodman cast-iron guns into 8-inch breech-loading rifles," submitting at the same time specific plans of alteration, &c.

Here is an illustration of the 100-ton Italian gun [exhibiting drawing of the gun] fired successfully; only carrying the construction to the higher calibers. What difference is there between that illustration and this? Why go through with tests with guns made upon that system when it has been so well tested by the French, Italian, Swedish, and other governments? I say, to-day, if the government wants that kind of gun, give the contracts and let them be made, and not waste time and money in going over these tests again. We can make the best cast-iron gun here that is made in the world, with the exception of, possibly, the Swedish gun foundries, and I doubt whether we are not equal to them. We can make the steel bands of any quality desired. If these are the kind of guns we want, as recommended by the Ordnance Department and the Getty Board, why not make them? But I say we want a better gun, a better system of breech-loading, and can produce it. But why should we make eight guns, five of them substantially alike in gun construction, and all on one system of breech-loading? Why not try some other plan? We know what the slotted-screw and what the Krupp systems are. We know they meet with difficulties; we know that the screw gets clogged; we know that the wedge sticks fast, preventing continued and rapid firing in many cases. Let us try and see if we cannot get something better. What has the Ordnance Department been doing all this time that its chief now comes forward and submits to the Getty Board these plans of guns on the French, Italian, and other systems? They have been well known for years. Here are the illustrations and records made by officers of the government. [Exhibiting.] The records are full of them. I could consume your time for days in showing records and reports in regard to these guns and others of similar construction.

I perhaps could answer the question why the Ordnance Department has not been bringing forward these guns that it now submits as a proper system to test.

The CHAIRMAN. Which guns?

Mr. MANN. These guns that they present to the Getty Board which is the slotted-screw system of breech loading; some with cast-iron body, banded with steel, some with steel tube wire wound.

The CHAIRMAN. If you can answer it, suppose you do. I should like to know.

Mr. MANN. I will try. This, remember, is the slotted-screw system. The Ordnance Department, as the records show, appears to have been devoting all its energies, since about 1875 or 1876, to the making, testing, and introduction into the service of what has been represented to Congress and the people as the Krupp system—the well-known and well-tried Krupp system—but, in fact, the Crispin patent system with the Krupp wedge. Crispin was chief constructor of ordnance and president of the Ordnance Board that had charge of the construction and testing of guns.

The CHAIRMAN. Do you say he is now?

Mr. MANN. He is not now. About a year ago when some of his guns went to pieces when under trial, one on the third, one on the eighteenth, and one on the one hundred and twenty-seventh round, and some other things occurred that I understand he was guilty of, he was relieved from his position. There is a copy of Crispin's patent, dated January 16, 1877. [Exhibiting No. 186,308 for "improvement in ordnance."]

Here are the illustrations of the guns as having been made by the Ordnance Department upon which they have devoted their energies, and a large expenditure of money and time during the past 10 years, until within a very short period, until these guns failed under proof.

The CHAIRMAN. They have failed?

Mr. MANN. They have failed utterly; past redemption.

The CHAIRMAN. How much has it cost the government?

Mr. MANN. I suppose there have been expenditures with the Crispin system of guns, probably amounting to over half a million dollars; I should say not in the making of the guns, but in making and testing them.

The CHAIRMAN. Has Crispin a patent?

Mr. MANN. Yes, sir. Here is the American patent dated January 16, 1877, No. 186,308.

The CHAIRMAN. You say that Crispin was the president of the Board?

Mr. MANN. He was the president of what was known as the old ordnance board, a permanent board in New York, that had charge of testing ordnance. He was also chief constructor of ordnance, having charge of the construction of ordnance.

The CHAIRMAN. Did the Ordnance Department know that he was the patentee of these guns when he was appointed on that board?

Mr. MANN. He secured his patents after he was appointed on the board; he was not the patentee when he was appointed on the board.

The CHAIRMAN. Who was?

Mr. MANN. He was appointed on the board shortly after the report of the Board organized under the act of Congress of June 6, 1872. I do not know the date of his appointment; it is a matter of record; but it was probably in 1873 or 1874 that he was appointed president of that board and chief constructor of ordnance. He obtained these patents while he was president of the ordnance board and chief constructor of ordnance; and it is fair to presume that the Chief of Ordnance knew of his having obtained them, and that these patented features were being introduced into the guns under construction by the Ordnance Department.

The CHAIRMAN. Was he the owner of that patent at that time?

Mr. MANN. I suppose he was the owner of the patent. It appears on record that he made the application and the patent was issued to him. I do not know whether he disposed of his patent or not. I understand not, for I understand that immediately after he made his statements to the subcommittee of the Senate Appropriations Committee, two years ago, that there was no provision for royalty to be paid on these guns

which were being made on his patent; but he did make a demand for royalty and received it.

The CHAIRMAN. Received it from whom?

Mr. MANN. I understand that he received it from Paulding, Kemble & Co., of the West Point foundry. I do not know it as a fact, I only know it as hearsay; but I understand that is the fact, and I have no doubt it can be shown to be true. I understand that he made a demand upon both the South Boston Iron Company, and Paulding, Kemble & Co. The South Boston Iron Company, I understand, refused to pay; refused it.

The CHAIRMAN. Had they made any of his guns?

Mr. MANN. I will give you a brief history of it.

The CHAIRMAN. Just answer.

Mr. MANN. Yes, sir.

The CHAIRMAN. How many?

Mr. MANN. They made one 8-inch; the Ordnance Board tested that, and they contracted for five more 8-inch, and for one 11-inch, and for four 12-inch. The 8-inch and 11-inch are converted guns, but the 12-inch was to be new guns; but they are all on the Crispin patent.

The CHAIRMAN. At what price?

Mr. MANN. I think the 8-inch guns were conversions of 10-inch Rodman guns, and it cost about $7,000 each to convert them. The 12-inch guns were to be made at a cost of $46,000 each.

The CHAIRMAN. How much would each gun weigh?

Mr. MANN. One hundred and twenty thousand two hundred and twenty-four pounds is the estimated weight of the 12-inch guns; the 8-inch weigh about 17,000 to 18,000 each.

The CHAIRMAN. How much ought they to have cost?

Mr. MANN. It was represented, I understand, to the Congressional committees.

The CHAIRMAN. I do not care what was represented. You are a gun-maker, as I understand?

Mr. MANN. I am in one sense a gun-maker, and in another sense I am not; I have no gun factory. I am not prepared to say, but what for making a first *experimental* gun that is a reasonable price; but to make four, I think perhaps they might be made for less, probably for $40,000; they are a pretty expensive gun to make. There is a steel part or socket used in these guns 42 inches in diameter, and forms the breech extension to receive the Krupp wedge.

The CHAIRMAN. But I am inquiring about the gun that was made.

Mr. MANN. Not one of the twelve-inch guns have been completed.

The CHAIRMAN. I thought you said there were four.

Mr. MANN. They were under contract and in course of construction, but when the eight-inch and eleven-inch guns failed while under test, which was before the contractors had cast the first one for the twelve-inch construction, as I understand, work was stopped, and remains in that condition to-day.

Mr. Chairman. I desire to call attention to another point, showing the inconsistency of the report of the Getty Board, and should be, in my judgement, a sufficient reason for the rejection by Congress of the entire report. The law under which the Board was convened made it the duty of the Board—

> To make examinations of all inventions of heavy ordnance and improvements in heavy ordnance and projectiles that may be presented to them, including guns now being constructed or converted under direction of the Ordnance Bureau; and said Board shall make detailed report to the Secretary of War for transmission to Congress of such examination.

In this examination they were to "*include guns now being constructed or converted by the Ordnance Bureau*," and "*make detailed report*," yet notwithstanding this *express instruction*, and the fact that *three* guns, constructed or *converted by the Ordnance* Department, *failed while under test during the sessions* of the Board—an 8-inch at the third fire, a 11-inch at the eighteenth fire, and an 8-inch at the one hundred and twenty-seventh fire, breech-loading guns, all converted upon the Crispin patent—the report of the Board, so far as I have been able to discover, contains *not one syllable* in reference to the *failure of these guns*.

You were asking me the reasons why the Ordnance Department had not taken up and tested these slotted-screw arrangements. I want to call your attention now to a matter of record—the recommendations of the Ordnance Board appointed under the act of Congress approved June 6, 1872, of which General Getty, the president of the Getty Board, was a member. The guns recommended for test by that Board were selected from some forty different plans. These were—of muzzle-loaders: Dr. Woodbridge's wire-wound gun and Mr. Hitchcock's wrought-iron and converted guns; of breech-loaders: Krupp's, Sutcliffe's, Thompson's, French, and Swedish—that is the gun recommended here by the Getty Ordnance Board—Mann's, and Lyman's multicharge.

In this list of guns selected by the Board for trial, no reference whatever is made to the Crispin patent breech-loader. The records do not show that any plan or description of this gun was before the Board of 1872, and it could not have been, for it was evidently designed subsequent to the meeting of that Board, and the patent was applied for by Colonel Crispin on December 1, 1876.

It is claimed by General Benét, Chief of Ordnance, and Colonel Crispin, that the making, testing, and introduction into the service of Crispin breech-loaders is fully warranted, and was provided for by the resolution of the Ordnance Board in its resolution of August 15, 1872. There were *two* resolutions passed by the Board on that date. The first one is as follows:

Resolved, That the Board recommends, in order to test the system of gun-conversion by lining with wrought-iron or steel tubes (as brought to the notice of the Board in a communication addressed to the Chief of Ordnance by Maj. S. Crispin, and referred to the Board by the Ordnance Bureau), that four 10-inch smooth-bore Rodman guns be converted to muzzle-loading rifles, using two calibers; two of the guns to have a caliber of not less than 8 inches, and two to have a caliber of not more than 9 inches; and, further, that two of the guns be converted by tubing from the rear end and two by tubing from the front; the character of the metel lining, whether of steel or wrought iron, and other details of conversion, to be determined by the War Department.

There is not *one word* in regard to a breech-loading gun of any kind in this resolution, and certainly does not provide for the Crispin breech-loader.

The second and only other resolution passed by the Board on August 15, 1872, reads as follows:

Resolved, That the Board recommends, in order to test the efficiency of the French and Swedish breech-closing arrangement, that a ten-inch Rodman smooth-bore gun, converted to a rifle in such manner and of such caliber, not less than 8 or more than 9 inches, as may be determined by the War Department, and conditional upon the success of tests, with the four 10-inch guns converted under the previous resolution, be provided with that *fermeture*, and the gun be submitted to test and experiment under the act of June 6, 1872.

It will at once be seen that this resolution contemplated a test of "the efficiency of the French and Swedish breech-closing arrangement"—which is the *slotted screw* and *not* the Krupp wedge—by the conversion of a 10-inch Rodman smooth-bore gun into an 8-inch or 9-inch breech-

loader, provided with the French and Swedish *fermeture*—the slotted screw. There is no reference in these resolutions to the Krupp gun, Krupp wedge, or Crispin patent.

The recommendations of the Board of 1872 in regard to the Krupp gun contemplated the purchase of Mr. Krupp, for trial, a 12-inch steel gun—nothing more and nothing less—and this was the only recommendation of the Board in regard to any test of the Krupp gun or the Krupp wedge. But the Board did clearly contemplate, and did recommend, a test of the slotted screw or French and Swedish breech-closing arrangement, by its introduction into a 10-inch Rodman gun, conditioned upon the success of the converted muzzle-loading guns referred to in the first resolution.

The Crispin gun is *an after-thought*, and comes up *three or four years after* the Board of 1872.

The first recorded indication of it is in 1875, through the Ordnance Board of which Colonel Crispin was president. It is subsequently *smuggled* in under the *guise* of the *well-known* and *well-tried* Krupp system, reciving the *unqualified* indorsement of the Ordnance Board of which Crispin is president, and is as *unqualifiedly approved and indorsed* by Gen-ernal Benét, Chief of Ordnance.

Meanwhile the guns that were recommended for test by the Board of 1872, and procured years ago at considerable cost to the government, have remained untried, and, as a result, their respective merits are undetermined and unknown. They have been in possession of the Ordnance Department since 1876, and some of them long before that date. The excuse given by the Chief of Ordnance has not been that they did not possess sufficient merit to warrant their being tested, but that there were no funds under the control of his department that could be used in testing their guns. While at the same time funds could be found with which to make and test official inventions and guns that were not provided for by law, or recommended except by a Board whose president was the patentee of the inventions and guns thus put forward to the exclusion of all others.

This is what I complain of. This is why I contend that the Ordnance Department is acting unfairly towards the citizen inventor and not for the best interests of the government.

It would seem that the Ordnance Department has been devoting most of its energies and efforts, and spending the public funds, in building up and fostering what is termed by some "Corps pride," and advancing the personal interests and schemes of some of its favored officers. But I am glad to know some of the officers of the Ordnance Corps do not approve of such a system of management by the Ordnance Department. They have found money and means to go on and convert a large number of guns which may possibly be all very well so far as second-class muzzle-loading guns are concerned, if it was not for the defective coiled tubes used in them; but they have failed to test the systems recommended by the Board of 1872. They have not tested one of them. Other plans and valuable improvements in ordnance have been brought to the notice of the Chief of Ordnance, and also the chief constructor of ordnance, but have met with no favor at the hands of the Ordnance Department. The guns have been made at large expense and lie at Sandy Hook all this time; yet they find money to make the Crispin gun and introduce it into the service to the exclusion of everything else; and then when the Getty Board is organized, they come before it with another system of breech-loading, and other systems of gun construction that have been before them all this time, and that were recommended by the Board of 1872.

Why did they not test them? It would not have cost them two thousand dollars to convert a 10-inch Rodman gun on the French and Swedish system of breech-loading, but Crispin has not a patent on it, and it was not done.

While I am on that branch of the business I desire to call your attention to another matter that may interest you. I have here from the United States Patent Office a certified copy of the file wrapper and contents in the matter of the letters patent granted to Silas Crispin January 16, 1877, No. 186308, for improvement in ordnance. In this file we find this letter:

NEW YORK, *December* 30, 1876.

Hon. COMMISSIONER OF PATENTS:

SIR: *In re* application of Silas Crispin for breech-loading ordnance, filed December 1, 1876, we shall be glad to have early action on the above case, in view of the fact that arrangements perfected for the immediate manufacture of the ordnance and delayed to await the issue of the patent.

Very respectfully,

MUNSON & PHILIPP.

Munson & Philipp were the patent solicitors for Crispin and acting as attorneys for him.

The patent issued upon this application is precisely the same as the guns made and tested by the Ordnance Department, and is dated January 16, 1877, No. 186308.

Colonel Crispin, chief constructor of ordnance and president of the Ordnance Board, delaying the government work awaiting the issuing of a patent! Then when outside inventors come up here and find fault with these things, we are called "disappointed inventors," "schemers," "muddling the brains of Congressmen." At the same time we see official inventors using the public funds upon their invention, and that with the knowledge and approval of the Chief of Ordnance.

Not only that; he goes to the British patent office and he secures a patent there. It is true the English patent is not in his own name. Mr. B. B. Hotchkiss, through Mr. William Morgan Brown, patent solicitors, of London, takes out the patent, which is precisely the same as Colonel Crispin's American patent. The English patent is dated June 5th, 1877, No. 2180, and no doubt is in the interest of Colonel Crispin.

The CHAIRMAN. How could he take out a patent on a thing that he did not invent?

Mr. MANN. In England the first man who makes an application for a patent gets it, regardless of who invented it.

The CHAIRMAN. Whether he invented the thing or not?

Mr. MANN. Yes, sir; whether he invented it or not; and it is a very common thing for an American inventor to send over there and have some party there take out his patent. Here is a patent for a gas-check for breech-loading ordnance issued to Colonel Crispin February 11, 1879, No. 212,197, that is introduced in these breech-loading guns. It may be a very good thing. I am not finding fault with that, but I am finding fault with the process and methods. Here is the English patent, dated March 14, 1879, No. 1019, for the gas-check, the same thing as Crispin's American patent. We see these things going on and our guns laid aside when they have given as good results, so far as tested, as any gun they have ever tested, and we want them tested. They have the money, they have the means; money is covered back into the Treasury, and yet we must not complain; it is wrong; we ought to submit to it, and let these official patented schemes go on and be made, tested, and introduced, to the exclusion of every other system regardless of the best interests of the government or the rights of the citizen inventor.

While we are on the patent business, here is Crispin's patent of February 4, 1879, No. 211,839, for lining tubes for ordnance. Here is Sinclair's patent of November 10, 1874, No. 156,822, for lining tubes for ordnance.

The CHAIRMAN. Who is Sinclair?

Mr. MANN. Sinclair is superintendent of the government proving grounds under Crispin, or was while Crispin was in charge of that department. Here are the converted muzzle-loading guns on which, I understand, one hundred and sixty dollars royalty on each is paid, with Sinclair's patent introduced into them. [Exhibiting drawings in report of the Chief of Ordnance.] There are numerous like cases of the Sinclair patents. Colonel Crispin gets the patent on his gas-check, and on his lining tube. Here is the gas-check that was introduced in all these guns. Here is his patent lining tube introduced into the guns. [Exhibiting drawings in reports of the Chief of Ordnance]; the same as is illustrated in his patent. Here is a 4½-inch gun converted on the Crispin patent system, introducing his patent arrangement for converting. [Exhibiting drawings in report of the Chief of Ordnance.] Here is more of the Sinclair patent tube. [Exhibiting drawings in report of the Chief of ordnance.] Here is another conversion of 3-inch guns on the Crispin patent system. [Exhibit drawings in the report of the Chief of Ordnance.] Here is more of the Crispin patent tube system introduced into the guns. [Exhibiting drawings in the report of the Chief of Ordnance.] Why, sirs, they manifest such a desire for conversions, that if they could have only had their own way, and Congress would keep up the appropriations, Moody and Sankey would have to retire from the field; they would have converted everything and everybody. Yet we must not find fault or complain.

It has been stated, if I am correctly informed, that I have no reason to find fault, but because I submitted my gun to the Getty Board and failed to secure the recommendation of the Board I am a sore-head, and all that sort of thing, because I have failed to secure recommendations for my gun. Let us see. My gun was recommended by the Board of 1872; it was recommended by the Board of 1868, and I will read you the names of the members of that Board: Bvt. Brig. Gen. P. V. Hagner, Bvt. Brig. Gen. T. J. Rodman, Bvt. Col. J. G. Benton, Bvt. Lieut. Col. S. V. Benét, Bvt. Col. Silas Crispin, Bvt. Lieut. Col. T. J. Treadwell, Bvt. Col. T. G. Baylor. General Benét is the present Chief of Ordnance. Colonel Baylor is president of the Ordnance Board having succeeded Colonel Crispin about a year ago. Speaking of that Board, I presented my system of breech-loading, and numerous other plans were presented, as the records show. The Board, in summing up its conclusions and making its recommendation, uses this language, which I think ought to mean something:

> Recognizing certain advantages in breech-loading over muzzle-loading guns for fortress service, and in order to test the relative strength of breech-loading and muzzle-loading guns, and other advantages of the breech-loading system, the Board recommend that two 12-inch cast-iron breech-loading rifles be made and tested, one on Broadwell's and the other on Mann's system, these being the most promising breech-loading systems now known to the Board.

One of Broadwell's and one of mine, "these being the most promising breech-loading systems now known to the Board." There is not a system of breech-loading ordnance known to-day that is of any consequence that was not known then.

What was the Broadwell system? Simply a Krupp breech-loading gun with a Broadwell gas-check inserted in the bore to prevent the es-

cape of gas between the wedge and the end of the bore. That was all there was of it. That is a pretty high recommendation for the Mann system, as one of the two best known to the Board, and since that time I have made valuable improvements on my system.

Now, to go back. In 1862 I brought to the city of Washington a 3-inch breech-loading steel field-piece, that was fired here at Battery Fox under the direction of Admiral Dahlgren 437 times. There is a representation of that field-piece [exhibiting photographs of the gun]. During the firing, when the men who had charge of the gun were down in the hollow, the officer in charge and myself sitting in a tent on the hill near by in conversation—it was a hot July afternoon—and the gun was fired 96 rounds in 76 minutes without interruption; that is, without any interruption of the working of the gun whatever; and the men who fired the gun afterwards said if they had known we were noting the time they could have fired it three times as fast—96 rounds in 76 minutes. Upon this successful trial of that field gun to that extent I accepted an order from Admiral Dahlgren for an 8-inch breech-loader rifle, to be made on the same plan. Mind you, this was in 1862, when there was no 8-inch rifle of any kind in this country that was known to be reliable. I took a contract to make that gun at my own risk and responsibility. The gun was made and completed in September, 1863, and here are photographs [exhibiting photographs of the 8-inch gun] of the gun as it was fired on the proving-ground, an 8-inch gun made in 1863 and tested.

The CHAIRMAN. A muzzle-loader or breech-loader?

Mr. MANN. A breech-loader, on my system.

The CHAIRMAN. On this system?

Mr. MANN. On this system; but I have made some very valuable improvements shown here now which have never been tested.

The CHAIRMAN. What was done with the gun?

Mr. MANN. That gun is now at Sandy Hook proving-grounds with some 40 projectiles prepared for it.

The CHAIRMAN. Never tested?

Mr. MANN. Never tested; only a few rounds; they could not find money to do it, and yet they covered money back into the Treasury.

Now in regard to the recommendations this system has received, I want to pursue that matter a little further. This 8-inch breech-loading gun was made in 1863 on an order from the Navy Department, and was subsequently transferred to the War Department. That is why it is in their hands to-day. This is the report of the naval officer who superintended the first trial of that 8-inch breech-loading rifled gun:

PHILADELPHIA NAVY-YARD, ORDNANCE DEPARTMENT,
September 25, 1863.

SIR: I have to report that, in obedience to bureau order of September 18th, I proceeded to Trenton, N. J., to superintend the trial of Mr. H. F. Mann's 8-inch breech-loading cannon.

The gun was slung in the usual manner from a gallows by rods 14 feet long, recoiling freely.

The inventor produced several metallic cartridge-cases, of the size of the chamber, pierced with a hole in the center of the bottom, this hole covered with iron gauze.

He proposed to fire with the same charges as are used in the service gun of same caliber, viz, Parrott's 150-pounder, 16 pounds, No. 7. Upon trial it was found that owing to some miscalculation this case would hold but 12¼ pounds. It was therefore filled with 12¼ pounds of navy cannon powder, in. vel. 1,436 feet, and fired seven times with the following results:

Let me say here that one of the important features in making a breech-loading cannon at that time, and is now, was to prevent the

escape of gas at the breech even if you could make the gun strong enough. That was one of the difficulties Sir William Armstrong had to contend with.

First fire.—Blank cartridge; no perceptible issue of gas; a piece of white paper placed in the rear of gas-check not soiled.

That was a piece of white paper placed in the joint covering the whole surface of the bottom of the bore between the barrel and breech-block.

Second fire.—12½ pounds navy cannon powder, contained in (copper) metallic cartridge-cases; shot, 121-pound cylindrical, with hemispherical end; fired with friction primer; gas-check of gun metal, ¼ inch thick, tapering to $\frac{1}{16}$ at edge; enters the bore 1¼ inches placed behind the cartridge.

After firing, the gas-check removed without difficulty by a hook; the bottoms of the cartridge case imbedded in the cup of the gas-check, but removed without difficulty; the cylindrical part removed with the hook; several small sand holes in the gas-check were made evident.

That was the first firing of the gun; everything was new, but there was no difficulty in working the gun. The cartridge-case was experimental and the gas-checks were made of metal that was more or less defective.

Third fire.—Same charge and weight of shot; cartridge-case tin, with copper bottom; tin body very much distorted and partially melted; paper showed no escape of gas.

Fourth fire.—Same charge and weight of shot; cartridge-case of copper; gas-check of brass. After firing, gas-check, which did not fit very well, showed that it had been swedged into the junction of breech-plate.

But this did not affect the working of the gun a particle.

Fifth fire.—Same charge and weight of shot; used the original gas-check.

Sixth fire.—Same charge and weight of shot. Having experienced some difficulty with the metallic cartridge-case, this charge was fired with the charge in the usual serge cylinder. Upon removing the gas-check it was found to be cracked for about 4 inches round the edge of the bottom of the cup. No perceptible escape of gas.

Seventh fire.—Same charge of powder; shot, 140 pounds; serge cylinder; recoil of gun, 7 feet.

Summary.—This could not be considered as a trial of any part of the apparatus, except the arrangement for preventing the escape of gas. The charge being but 12½ pounds in lieu of 16 (one-fourth less), and all of the shot but the last were but 121 pounds (one-fifth less) weight.

The arrangement for opening and closing the breech worked freely and accurately. The breech-block has a movement of one-fourth of an inch, which is supposed to be ample to allow for expansion, and to permit the breech to close in the event of the gas-check not entering freely.

It will require some means, which the inventor has no doubt he can arrange, for drawing back this breech-block after firing, in case the gas-check cannot be forced home by hand.

The chamber must be lengthened about two inches to enable it to contain the service charge.

All the projectiles provided by the inventor were fired, and the gun remains in position to await the further order of the Bureau.

The weight of the gun is 20,000 pounds; length of bore, 12 feet; total length, 15 feet; turn of rifling, 1 in 80 feet. All the shot took the rifling well and struck the butt—distant 15 yards—point foremost.

I am, very respectfully, your obedient servant,

WILLIAM N. JEFFERS,
Assistant Inspector of Ordnance.

Commander H. A. WISE,
Chief of Bureau of Ordnance (ad interim),
Navy Department, Washington, D. C.

Forwarded by—

C. K. STRIBLING.

So it goes on through. That is the report of the first trial of the 8-inch gun. On the 20th of November, 1863, the same gun was fired under the direction of another officer of the Navy Department.

I have here a copy of his report, which I will not take time to read:

No. 459.] PHILADELPHIA NAVY-YARD, ORDNANCE DEPARTMENT,
November 20, 1863.

SIR: I have the honor to report that, agreeably to your order of 14th instant, I have visited Trenton, N. J., for the purpose of firing the breech-loading gun of Mr. H. F. Mann.

Major Laidley, U. S. N., in charge of the Frankfort Arsenal, was, by direction of the War Department, present.

The "charges of powder and implements necessary for the service of the gun" were duly received from this yard.

I found the gun to be, in every respect, as described by Lieutenant-Commander Jeffers, in his letter of 25th of September, ultimo, to the Bureau of Ordnance, with the exception of an increased capacity of chamber, which now admits the 16-pound charge.

Everything being in readiness, the firing was commenced at 11 a. m. yesterday; weather clear and bright.

The charge was invariably 16 pounds, Curtis and Harvey, No. 7, in flannel bags.

Shot solid and conical, with two 1¼-inch cuffs of soft metal; mean weight of ten shot, 146 pounds.

First fire.—No perceptible escape of gas about the breech; the gas-check one that had been used in former trials.

Second fire.—A new gas-check was used; friction primer failed on first trial to explode the charge; no escape of gas; a part of the suspension rods giving way; stopped to repair.

Third fire.—No escape of gas.

Fourth fire.—The result the same as the previous fire, except that the gas-check was cracked.

Fifth fire.—The result the same.

Sixth fire.—Some little evidence about the breech of escape of gas. The breech-block was not, however, pressed up very hard.

Seventh fire.—The gas-check fractured, as heretofore, about the hole in the center of cup; no perceptible escape of gas.

Eighth fire.—The result the same as in previous fire.

Ninth fire.—A thinner gas-check was substituted; some little escape of gas, and the gas-check indented.

Tenth fire.—The result the same as previous fire.

At this, the last round, the suspension rods gave way, letting the gun down to the ground and putting an end to further firing.

As it will take several days to resling the gun, and the inventor expressed his intention of conferring in person with the bureau as to the propriety of continuing the proof with the gun mounted *on a carriage*, I have returned to my duties at this yard.

In my judgment an iron carriage might be forwarded from the Frankfort Arsenal, with some inconsiderable changes to suit the piece, when not only the remaining 40 rounds ordered by the bureau could be fired, but the piece might be also put through the service proof, if desired.

The present arrangement for slinging the gun has not sufficient endurance.

I had not a full opportunity of testing the facility of loading, as the rear suspension rods greatly interfered with that operation; but I believe the operation may be executed more rapidly than in a muzzle-loading piece.

The gas-checks used were cast of a composition evidently defective. The inventor believes he can overcome the difficulty, and give a much longer life to this—as he considers it—important appliance.

There was no difficulty in removing the gas-check, which was found to be cold after every discharge, and no force necessary to set back the breech-block.

The gun was served by eight men, four being necessary to throw up the gun for loading. It would be no difficult matter to so multiply the power as to require but one instead of four men for this purpose, two to serve the shot, with a captain and powder man.

After the tenth round a careful examination developed no evidence of strain.

It is very evident that the length of trunnion straps, screws, and breech-block of this gun would require its carriage to be of "disproportionate height."

In suggesting this fact to the inventor, he expressed the belief that by settling the trunnions nearer the breech and reducing the length of straps, &c., to their minimum size, the objection, to some extent, might be removed.

I am, very respectfully your obedient servant,

J. H. UPSHUR,
Assistant Inspector of Ordnance.

Commander H. A. WISE,
Chief of the Bureau of Ordnance (ad interim),
Navy Department, Washington, D. C.

Forwarded by—

C. K. STRIBLING, *Commandant.*

Here is another report of the same firing by another officer.

At my request to the Ordnance Department of the War Department, Colonel Laidley was directed to go to Trenton and witness the firing of the gun and make reports. I will simply read his summing up and put in the full report:

FRANKFORT ARSENAL,
Bridesburgh, Pa., November 20, 1863.

GENERAL: I have the honor to report that in obedience to your instructions of the 16th instant, I proceeded yesterday to Trenton, N. J., and witnessed the firing of Mr. H. F. Mann's 8-inch breech-loading rifled gun.

The gun was suspended by means of iron rods attached to stirrups passing under the trunnions and to eye-bolts in the breech-transom.

After the second shot it was found that one of the eye-bolts was badly cracked; it was replaced by a new one.

On the tenth round the gun was dismounted, and firing terminated by two of the suspension rods giving away.

The charge used was 16 pounds of powder and a shot weighing 146 pounds, with two bands of soft metal around it.

The mechanism for opening and closing the chamber worked satisfactorily. The escape of gas at the breech at any one time was barely perceptible. Four men were sufficient to load and fire.

After the tenth shot there was not the least indication of any yielding or giving way of any part of the gun, but it seemed to be in as good condition now as before it was fired.

It is highly desirable, in testing endurance of this gun, to get its range, the accuracy and rapidity of fire, the initial velocity of the shot, and the pressure of gas in the bore, and for this purpose I recommend that the gun be removed to some better place, and that it be mounted on a regular carriage.

Very respectfully, I am your obedient servant,

T. T. S. LAIDLEY,
Brevet Major.

Brig. Gen. GEO. D. RAMSEY,
Chief of Ordnance.

ORDNANCE OFFICE, WAR DEPARTMENT, *November 24th*, 1863.

True copy.

J. C. LYFORD,
Lieutenant of Ordnance, Asst. to Chief of Ordnance.

NOTE.—The suspension rods referred to were no part of the gun, but were used to suspend it in the temporary frame for proof test.—H. F. MANN.

That was Colonel Laidley's report. Now we come to General Rodman, who was standard authority on ordnance in this country up to the time of his death, and he is referred to now as such. He was directed by General Dyer, then Chief of Ordnance, at my request, to make examination of my gun and make a report of his examination. The gun was then at Fortress Monroe. He reports as follows:

ORDNANCE OFFICE,
Washington, January 22, 1867.

GENERAL: In compliance with your instructions of the 26th ultimo, I have considered and examined the subject of breech-loading cannon, and especially the systems of H. F. Mann and L. W. Broadwell, the only two that have been offered in anything like a practically developed state.

I have examined the 8-inch rifle of Mr. Mann, now mounted at Fort Monroe, and witnessed the firing of a number of rounds from it.

It is in working order, and will, in my judgment, answer as a representative gun of Mr. Mann's system, and serve to compare it practically with other systems. I have also examined Mr. Broadwell's breech-loading field-piece, and witnessed the firing of several rounds from it, and would respectfully recommend that a 12-inch rifle be constructed upon Mr. Broadwell's system, and that it be mounted by the side of Mr. Mann's gun, and that a board of not less than three competent officers be appointed to fire these guns, first, to determine the relative merits of the two systems in both casemate and barbette service; second, to determine the relative merits of the superior one of these two systems for casemate or barbette service, and that of muzzle

loading guns of the same caliber; and third, should the breech-loading prove superior to the muzzle-loading system, then to determine the relative endurance of breech-loading guns of the same caliber.

Speaking of Mann's and Broadwell's systems of breech-loading at that time:

Drawings of Mr. Mann's 8-inch gun, and of Mr. Broadwell's *proposed* 12-inch rifle, are herewith submitted.

I would recommend that the rifling of the 12-inch Broadwell gun be the same as that of the 12-inch rifle now at Fort Monroe, *except* the *twist*, which I would recommend to be one turn in 60 feet.

Respectfully, your obedient servant,

T. J. RODMAN,
Major and Constructor of Ordnance,
Brevet Brigadier-General, U. S. A.

Bvt. Maj. Gen. A. B. DYER,
Chief of Ordnance, U. S. A.

I was not permitted to have a copy of that report by the Chief of Ordnance. After a long siege I was permitted to hear it read in his office. When the Joint Select Committee on Ordnance was organized by Congress several years ago, I was enabled to get a copy with this certificate:

I certify that this is a correct copy of the report transmitted to the Joint Committee on Ordnance by the Chief of Ordnance of the War Department.

V. E. SMALLEY,
Clerk Joint Committee on Ordnance.

Here is also another report by an officer of the Ordnance Department, who fired my 8-inch breech-loading gun a number of times, and recommended its further test:

FORT MONROE ARSENAL, VA.,
May 1, 1865.

SIR: I have the honor to report, that in obedience to your instructions, I have fired the breech-loading gun of Mr. Mann's invention, with the projectiles furnished by him, and transmit herewith a target record of fire, giving in detail the results obtained.

As a drawing of this gun and the projectiles fired from it has been furnished you by Mr. Mann, no description of either is necessary in this report.

The number of projectiles fired was hardly sufficient to test the merits of the gun. The main points which could be decided by this firing, were the range and velocity with a given charge and pressure, as compared with other guns of the same caliber, and whether the device for closing the breech could be worked with facility and perform properly its office.

All the information obtained with regard to the first point is given you in the target record. With regard to the second, I would state that the breech was opened after firing, the gun loaded and the breech closed without difficulty, and in about the same time and with the same number of men as would be required to load a muzzle-loading gun of the same caliber. Although gas escaped freely at the breech, the consequent fouling of the parts did not interfere at all with working them freely, and would not, I think, even should the gun be fired continuously and rapidly.

In the firing, gas-checks were used with a view of preventing the escape of gas at the breech. At the first fire, one of copper was used and seemed to prevent all escape. The same gas-check was used at the second and at the last eleven fires, but failed* altogether to prevent the escape; at the other seven fires, gas-checks of cast and malleable iron were used. These were broken at the discharge, and of course failed to perform their office.

A great defect in the gun is its preponderance of nearly one ——— pounds, which interferes materially with rapid maneuvers. I do not see, however, that this is at all necessary, and if other guns should be made, I presume the axis of the trunnions might be thrown near the center of gravity. It is also questionable, I think, whether the grooves of the gun have a sufficient twist, viz, one turn in 80 feet. Most of the projectiles fired took the rifle motion well, but they were shorter and lighter than

*NOTE BY H. F. MANN.—Meaning that the gas-check used did not prevent *all* escape of gas.

those usually fired from guns of this caliber. Their length was 13 inches and weight 113 pounds.

An examination of the table of fire will show that the results obtained compare favorably, so far as range and velocity with a given charge and pressure are considered, with the results obtained with other guns.

At the close of the firing, the bore of the gun was carefully examined and showed no signs of having been in any way injured.

I would respectfully suggest that the firing be continued to test the endurance of the gun.

Respectfully, your obedient servant,

THEO. EDSON,
Captain of Ordnance, Commanding.

Brig. Gen. A. B. DYER,
Chief of Ordnance, Washington, D. C.

Yet we ought not to complain. Here is a report made by General Rodman, in pursuance of my special request that he should make it. There is a report of the firing in May, 1865, at Fortress Monroe. I will not trouble you by reading it. General Rodman saw this gun fired several rounds when he made that report. What I complain of, and what I want Congress to rectify, is this delay and difficulty in getting a test of a gun that presents so many valuable features, and that has been recommended so many times for test, and I come here to set myself right in these respects in regard to the great injustice done me by the report of the Getty Board.

I want it to be understood that I do not object to officers of the Army and Navy making inventions and improvements and securing patents for them, and securing in a proper way all the benefit they are entitled to from them. I think that is a proper thing to do; I think it is commendable, yet, when we see such a programme and such practices as has been carried out under the sanction and direction of the Ordnance Department in the last few years in connection with this Crispin matter, I think it is damnable. Neither would I wish to detract one iota from the credit that is due to any other inventor. I would give him all the privileges and consideration I ask for myself, and even more; but what does the Getty Board propose to do? It rejects a gun that the president of the Board once, as a member of another board, recommended; but when I present it to his Board, with recent valuable improvements, they decide against it, and say it is not worthy of test; giving reasons which are inconsistent and unwarranted by the records and facts; but they come here with recommendations, and Congress is presumably asked to carry them out, in favor of eight guns, all to be made on one system of breech-loading, and five of which are upon the system of wire-winding system of gun construction. So far as the wire winding is concerned, it is no new thing; it has been tried years ago. There is no doubt in my mind but what in one direction a gun made on the system of wire winding would be a very strong gun, but in the other directions it is an exceedingly weak gun. The 10-inch Woodbridge wire-wound gun was the only gun the Getty Board tested during their sessions; and it failed on the ninety-third round. I want to say right here in this connection, that the 10-inch Woodbridge gun made on the wire-wound system, which was tested by the Getty Board, and that now comes up as the system that shall be tested to the extent of *five guns out* of the *eight*, has been before the Ordnance Department, for several years. It was made under the recommendations of the Ordnance board of 1872, and completed in July, 1876, a 10-inch Woodbridge gun—a wire-wound gun, supposed to be pretty well made, and a very strong gun. Yet the Chief of Ordnance and the Ordnance Department could not find time to fire it; but the Getty Board takes it up and fires it, and what is

the result? There are photographs showing how it failed [illustrating]. The Board have recommended *five* guns *out* of the *eight*, to be constructed on the wire-wound system.

The CHAIRMAN. Then I disapprove of that recommendation, though I do not know anything about it.

Mr. MANN. That is what the Getty Board did. There [exhibiting] is one 10-inch Woodbridge gun wire wound; here [exhibiting] is another cast-iron gun wire wound; here [exhibiting] is a steel tube and longitudinally bars wire wound.

These are drawings of the guns recommended by the Getty Board. Here [exhibiting] is a gun proposed by the Chief of Ordnance, wire wound, like the Armstrong wire gun almost line for line; and here [exhibiting] is a gun proposed by Colonel Crispin, wire wound; these are all drawings of wire-wound guns recommended by the Getty Board. This 10-inch wire gun was fired up to 93 rounds and ruptured under a pressure supposed to be 74,400 pounds to the square inch. I think it is proper and right that Dr. Woodbridge should have another opportunity. Undoubtedly wire winding makes a strong gun in one direction and a very weak one in the other, and if he can overcome the weakness, we may get a good, reliable gun; that is what we want. But why should the Getty Board recommend you to make five out of eight guns on that one system, and those *eight* guns *all* on *one system* of *breech-loading*? If we want to find out which is the best, let us try more than one and more than two. Here is the system that I present, a breech-loading system that has had the indorsement of some of the best engineering talent of the country, including the highest ordnance officers of the country, including the present Chief of Ordnance. Why not give that a simple trial, and see whether we cannot get a breech-loading system of ordnance that is reliable? It never has been tried. How do we know? We cannot know if we try slotted screws all the time, putting it into all the guns we are to make. If we want to make half a dozen wire-wound guns, let us make one on one system of breech-loading, and another on another system of breech-loading. I have no objection to the wire winding if they want to use it. I can use it in my system better than they can in in any other, so far as strength is concerned, and the Board admit it. Why not try it? If they want a cast-iron barrel banded with steel, I can use it as well as anybody, because I provide longitudinal strength with these straps. Wire wound guns and guns of other construction have failed for want of sufficient longitudinal strength, and therefore fail by transverse rupture.

The Getty Board admits that with my system I provide greater security against transverse rupture; that it gives greater longitudinal strength. Is this not what we want, what we have been trying to obtain in order to make a safe and reliable gun? The Board object to my system of breech-loading, giving as one of its reasons that it does not approve of the construction of the barrel I presented with my gun. Why, sirs, I am not confined to this construction of gun-barrel. I can use any construction of gun-barrel that is *known to be good*. I can apply my system of breech-loading to any one of the systems of gun-barrel constructions that was recommended by the Getty Board, excepting the Schultz plan presented by Colonel Crispin.

The CHAIRMAN. I do not think it necessary for us to take a great deal of time in a discussion about which gun ought to be or ought not to be recommended. I would rather that each man should give the merits of his own gun and make a proposition to the committee to be laid before Congress.

Mr. MANN. I will do that.

The CHAIRMAN. You have discussed the merits of your gun. Now, what is your proposition? Let us have that.

Mr. MANN. My proposition is to have my system of breech-loading thoroughly tested by the government.

The CHAIRMAN. What do you propose? Suppose you were to make an 8-inch gun or a 12-inch gun weighing 120,000 pounds, or whatever the gun will weigh, what would you make a gun of that kind for, for testing, or if the government like it, what would you make a number of guns of that kind for? What would they cost? Suppose you had a contract for fifty guns like that, what would you charge per gun for an 8-inch and a 12-inch gun?

Mr. MANN. I would make 12-inch guns on that basis for $28,000 each, for 12-inch guns in numbers of, say, fifty.

The CHAIRMAN. Weighing how much?

Mr. MANN. That would weigh as the Board report states, about 129,000 pounds. That is an estimated weight of a 12-inch gun 30 calibers long. An 8-inch gun would cost about seven to eight thousand dollars. I have put it down a little low at $6,800 for a number of guns. A single 8-inch gun for experimental purposes would be worth probably $12,000, and a 12-inch, $40,000. However, we will consider these approximate prices, and I will submit a more definite proposition at another time.

The CHAIRMAN. I want each man to make a proposition to the government, if his guns are tested and prove successful and the government wants them, at what price he will make the two kinds of guns. I want something in the nature of a proposition for a contract.

Mr. MANN. That is a fair proposition, and I will say now, as I said to the Board, I will furnish 12-inch guns of this character in lots of one hundred or more, at $28,000.

The CHAIRMAN. Suppose we did not want one hundred, but fifty.

Mr. MANN. Well, say fifty; I will make the 8-inch gun at $7,000 each.

The CHAIRMAN. When you say "the gun," I suppose you mean it with all the apparatus connected with it? You do not mean the gun carriage with it, or do you?

Mr. MANN. I mean the gun ready to mount on its carriage.

The CHAIRMAN. With screws and all the appurtenances connected with it.

Mr. MANN. Yes, sir; I present a system of breech-loading that is the most easily and simply constructed of any material that is available. There is no question in my mind that steel is better than cast-iron *when we can get it* in large masses of the proper quality. We use it in many cases in preference, but the difficulty is in getting a reliable quality in large masses.

The CHAIRMAN. When you speak of making these guns for that price, what kind of material do you propose to make them of?

Mr. MANN. That was supposing the barrel to be made of cast-iron banded with steel at the breech over the charge chamber, which I can do in a better way than can be done with any other system that is proposed.

The CHAIRMAN. You mean that that is all the steel there shall be about it?

Mr. MANN. Yes, sir; except the breech-screw. I put in a steel breech-screw. The balance of it would be wrought iron. The side straps and breech transom and the small parts would be wrought iron. The barrel would be cast iron banded with steel. Of course, if you make the

gun of steel, whenever we get to the point that we can make steel of the size required as reliable as cast iron is now made, we can make that much better gun. I mean steel as reliable as cast iron for the purposes for which it is used; but I may say here that the records show as much endurance of cast iron in the shape of a gun as steel guns have shown. There has been a great many failures of cast-iron guns, and there has also been a great many failures of steel guns, but the records show that cast iron has stood as severe tests as steel ever did.

Now, I want to call your attention again to the simplicity of this system as a breech-loader, and to its practicability. In the Krupp gun there is a wedge. Of course I have only the small wedge here. I cannot show you by this model all the little delicate contrivances that are used for operating that wedge. You have an illustration of some of them here. [Exhibiting a drawing of a Crispin Krupp gun.] Now, suppose a shot strikes the sand near the gun when it is open and sand is thrown upon it in the midst of a battle, and it is important to deliver the next shot at the earliest possible second, you have sand on that screw and on these delicate parts, and you must stop to clean up. It is not the case with my gun. You may throw a barrel of sand over this gun and it can be operated.

The CHAIRMAN. If a barrel of sand was thrown in it, it could not operate very well.

Mr. MANN. That would be so with any gun; but you may throw a barrel of sand into it and I can clean it out and have my gun ready for operation four times quicker than you can either of the other people's systems, because all I have to do is to run a swab through the bore, whereas, if you run a swab through the others, you foul the breech and the screw, as I can show by the records. Not only that, I have here an illustration. [Exhibiting a Parker breech-loading shot-gun.] There is no difficulty in loading and firing that gun.

The CHAIRMAN. Is that made on the same plan?

Mr. MANN. On a similar plan. The action is similar in every way. There is no screw; there is nothing to get out of order; there are no small delicate parts connected with the breech-loading arrangement I present as there is in the Krupp wedge and slotted screw systems.

All I want, Mr. Chairman, is a fair trial of my system; that is all I have contended for. If it is valuable I want the government to have the benefit of it, and of course I expect to derive some little advantage from it myself. If some one else has a better system, I will take a back seat when I have had a fair chance in a competitive trial.

In the construction of a gun we have to provide for strength to resist different strains. As you will observe from the rupture of the Woodbridge gun, while it is abundantly strong to resist one strain it is very weak in the other direction—it lacks longitudinal strength. It is the history of all wire winding. I could show you from the records that wire-wound guns and a great many other guns—I have here the record of the Ordnance Department to show—that guns that are too weak to resist transverse rupture blow off at the breech. I have here Ordnance Note No. 187, in which is published a paper read by Colonel Maitland, who is superintendent of the Royal Arsenal at Woolwich, before the Society of Arts, in London, in February last. Speaking of the wire-wound guns, he says:

> You will readily understand that a gun can be thus formed having enormous strength to resist bursting. Unfortunately the wires have no cohesion with one another, and the great difficulty with construction of this kind is to obtain what gun-makers call end strength.

That is, to resist blowing off at the breech.

It is of but little use to make your walls strong enough if the first round blows the breech out. In the early days of wire this was what happened, and Mr. Longridge, who invented the system, was compelled to abandon it.

Lately methods have been devised in France, by M. Schultz; at Elswick, by Sir W. G. Armstrong & Co.; and at Woolwich by ourselves, for getting end strength with wire guns. They are all in the experimental stage; they may prove successful, but I prefer not to prophesy at present.

It is still doubtful whether they will be able to get sufficient end strength in wire guns. They are undoubtedly strong enough in the other direction to resist bursting, but the end strength is where the difficulty comes in.

Sir William G. Armstrong, in an address delivered before the Institution of Civil Engineers, January 10, 1882, says, speaking of hooped guns, and the same principle holds good in wire guns:

It is to be observed, however, that mere hoops shrunk upon an internal tube give no end strength to the gun, and the tube must in that case be made sufficiently thick to carry the whole longitudinal strain. But since a thick tube approaches the objectionable condition of a solid gun, it is better to reduce the thickness of the tube and supplement its deficient end strength by longitudinal strength in the surrounding material.

There we have high authority for the deficiency of end strength. Here we have other authority. I have the record of firing an 8-inch breech-loading rifle No. 5, by the Ordnance Department, one made on the Crispin plan with the Krupp wedge, that shows a deficiency of end strength [exhibiting official records and drawings]. If it had had sufficient end strength the breech would not have blown off at the third fire. Here [exhibiting records and drawings from the Ordnance Department], is an 11-inch breech-loading gun on the Crispin system with the Krupp wedge, that lacked strength; it pulled off at the breech at the eighteenth fire. There was also another 8-inch gun that had the same difficulty, made on the same plan. I have here, in Holly on Ordnance, one of the best works and authority, an illustration of what is called the Schultz or French system of longitudinal rods outside; that is brought forward, having been recently imported into this country, by Colonel Crispin. Colonel Crispin brought this with him from Europe, and the majority of the Getty Board recommend it for test. That system of gun was tested by Mr. Blakeley; Mr. Longridge tested the same system by wire winding, and found it deficient in end strength.

Now, take a common muzzle-loading gun, and in firing it we subject it to two kinds of strain that are considered the most severe on a gun—the longitudinal and the transverse. If we can dispense with the longitudinal strain and obtain the strength of metal that is required to resist the transverse strain, or the strain which has a tendency to burst the gun, if we can relieve that metal of the longitudinal strain, we accomplish, I think, a great deal. If we can throw the longitudinal strain upon independent material we can get a better gun, we can get a safer gun; we can also get a gun that is not so much affected by the expansion and contraction of the metal, which is a very serious matter we have to contend with in a gun.

In the construction I propose, the barrel of the gun is entirely relieved of this longitudinal strain, or the tendency to blow off the breech. I relieve the barrel of that strain. I bring these side straps into play outside of and independent of the barrel and of the influences of the charge of powder, so that, so far as any heat or expansion or construction is concerned, they are not affected, and make

them transmit the longitudinal strain to the carriage. I have a much better gun, and a gun that is more simple and more easily constructed.

There is no more practical difficulty in constructing that gun than there is in constructing a steam engine; it is just as easily calculated. An engineer can calculate the strength necessary in the parts of a steam-engine, and an ordnance officer can calculate the strength necessary of these side straps to resist 30,000 or 50,000 pounds pressure to the square inch in the bore. All he has to do is to know the elastic limit of the material that he is to deal with and the pressure in the bore of the gun, and he arrives at it practically with absolute certainty; and so with the transverse strain, we can as readily calculate the transverse strain knowing the strength of the material.

So I contend that with this construction, this system of breech-loading, a gun can be made that is stronger, more simple, safer, and more easily operated than any system or construction that has been presented; a gun that can be fired day in and day out without any difficulty whatever. There is no more reason why that gun, as a 12-inch gun, should fail in firing it as rapidly as it can be handled than there is in this gun [exhibiting the fowling-piece before referred to] that you take into the field with you. It is just as certain in its operation.

The Krupp wedge and slotted-screw systems of breech-loading make a complicated piece of work; but with my system the construction is perfectly simple; it is accessible; there are no small parts to contend with as in the others; we thereby get a better gun, a more reliable gun, and a safer gun. That is what I contend for, and I contend that the government ought to know for its own benefit, leaving my interest out of view entirely, and ought to decide whether I can produce, or whether it can produce, by this system a gun that is more reliable than the constructions it has been dealing with. That is all I want. If the gun is tested and fails, I will retire in as good order as possible; but I believe, and I have had reason to believe, I have had the recommendations and the opinions of the highest engineers in this country that I had a good system. Major Wade, who was considered high authority in ordnance matters, told me years ago that there was no sort of doubt about my being able to make a gun on my plan of breech-loading that would stand firing with perfect safety; and in the details of its construction the plan I propose now is much better than it was then.

I have said, perhaps, all that is necessary. I think I can claim credit for having, as a private citizen of the United States, contributed more to the development of a good and reliable system of breech-loading ordnance than any other man in this country. I made a 3-inch gun and brought it here at my own risk and expense in 1862; I made an 8-inch breech-loading gun at my own risk and expense in 1863. I have made valuable improvements recently which make the gun much better than it was before.

Mr. Chairman, I desire to say a word in regard to the proper tests that, in my judgment, should be made by the government. The Getty Board recommend for test eight guns, all to be made on the slotted-screw system of breech-loading, five of the eight to be of the wire-wound system of gun construction.

The CHAIRMAN. You stated that before.

Mr. MANN. Yes. But what I want to get at is this: The Navy Department, as stated in official reports, is putting under construction a wire-wound gun on the Woodbridge system of gun construction with the slotted system of breech-loading that will settle that point either one way or the other, in all probability. That gives the wire-wound

system a second trial. The steel-hoop or banded gun is another system of gun construction with the slotted-screw breech-loading arrangement that they undertake to solve. They have the money appropriated to do that. What I want to suggest now is, if the committee think it wise to do so, that a sufficient amount of money be appropriated to enable me to have my system thoroughly tested in comparison with other systems.

The CHAIRMAN. That is the application; we understand that.

Mr. MANN. But some of the guns or systems recommended by the Getty Board are already provided for, and are being made for tests and experiment by the Navy Department. These trials, as I understand, will include a gun on the steel wire-wound system of gun construction, and a steel gun on the steel-banded system of gun construction, both guns to be made on the slotted-screw system of breech-loading. The tests of these guns will probably determine the relative merits of the two systems of gun construction, and also of the slotted-screw system of breech-loading applied to those systems of gun construction.

Now, Mr. Chairman, I think I have clearly shown and demonstrated by the records and facts the inconsistency and unfairness of the recommendations of the Getty Board, and that by its report in reference to the improved system of breech-loading rifled ordnance submitted for its consideration by me, the Board has done me very great wrong and injustice. It seems to have failed to determine *for itself* by a course of sound reasoning, scientific or theoretical investigation, as to whether a breech-loading rifled gun *could* or *could not* be made upon the system I submitted that would be a stronger, more durable, and a safer gun; one more easily and rapidly fired, or that would endure firing with larger charges of powder and weight of projectile than the guns on other systems recommended by it for test; or that guns on my system could be constructed of any materials or combination of materials that is now known, or might be found to be the best and most reliable; or that any well-tested and approved plan or system of "gun construction" could be used in connection with my system of breech-loading, and that therefore the Board has failed to comprehend the merits and advantages of the system of breech-loading rifled ordnance submitted to it by me. I have also shown that the Ordnance Department has been expending almost its entire efforts for years past, and using large sums of public funds, in the development and advancement of the patented schemes and personal interests of some of its officers and employés, in utter disregard of the rights of citizen inventors and of the best interests of the government.

Mr. Chairman, I now desire to submit the following as an approximate estimate of the cost of a single breech-loading gun constructed upon my system of breech-loading for each of the calibers named, with the estimated cost of firing each to the extent of 500 rounds; also the price at which they could be furnished to the government in greater numbers:

Estimated cost of H. F. Mann's high-power breech-loading rifled guns of the following calibers for test by the government, with probable cost of firing each to the extent of 250 rounds:

EIGHT-INCH.

One 8-inch high-power breech-loading rifle	$15,000
250 rounds of powder	5,000
250 projectiles	4,625
Preparation of 10-inch army carriage and platform	1,250
Labor, &c., during test	2,500
Total cost of gun and firing 250 rounds	28,375

TEN-INCH.

One 10-inch high-power breech-loading rifle	$28,000
250 rounds of powder	8,750
250 projectiles	8,750
Preparation of 15-inch army carriage and platform	1,800
Labor, &c., during test	3,250
Total cost of gun and firing 250 rounds	50,550

TWELVE-INCH.

One 12-inch high-power breech-loading rifle	$46,000
250 rounds of powder	15,000
250 projectiles	16,250
Preparation of carriage and platform	8,000
Labor, &c., during test	3,900
Total cost of gun and firing 250 rounds	89,150

The above estimates of cost are for a single gun of each caliber for test; the barrels to be made of cast iron banded with steel bands at the breech over the powder chamber, the side straps, breech transom, &c., to be made of the best forged charcoal iron.

These guns could be furnished in lots of 50 or more at the following prices:

8-inch each	$7,000
10-inch each	16,000
12-inch each	28,000

STEEL GUNS.

Estimated cost of H. F. Mann's full high-power all steel breech-loading rifled guns for test by the government.

SIX-INCH.

One 6-inch full high powder breech-loading rifle, *all steel*	$15,000
250 rounds of powder	3,250
250 projectiles	2,250
Preparation of army carriage and platform	1,200
Labor, &c., during test	1,750
Total cost of gun and firing 250 rounds	23,450

EIGHT-INCH.

One 8-inch full high-power breech-loading rifle, *all steel*	$24,000
250 rounds of powder	6,375
250 projectiles	4,625
Preparation of 10-inch army carriage and platform	1,500
Labor, &c., during test	3,000
Total cost of gun and firing 250 rounds	39,500

TEN-INCH.

One 10-inch full high-power breech-loading rifle, *all steel*	$35,000
250 rounds of powder	10,625
250 projectiles	8,750
Preparation of 15-inch army carriage and platform	2,000
Labor, &c., during test	3,250
Total cost of gun and firing 250 rounds	59,625

The estimates for *all steel* full high-power breech-loading rifled guns are for a single gun of each caliber for test, andare to be made of the *best quality of steel*, and to be *full high-power guns in every respect.*

These all-steel guns could be furnished, in lots of 50 or more, at the following prices:

6-inch, each	$9,000
8-inch, each	16,000
10-inch, each	26,000
12-inch, each	40,000

I now respectfully request your committee to recommend to Congress that a sufficient sum of money be appropriated to enable the Secretary of War to procure and properly test one or more breech-loading rifled guns constructed upon my system of breech-loading, with the necessary projectiles, powder, &c., such test to be at least to the extent of firing 502 rounds.

If I may be permitted to make the selection of the size of guns to be made and tested, I would suggest one of 8-inch caliber and an *all-steel* gun of the same caliber.

In order to properly determine the relative merits of guns constructed upon the same design but of different materials or combination of materials, it is necessary to subject them to practical comparative tests; so that by a practical test of the two guns I suggest, an 8-inch breech-loading rifle, made with a cast-iron barrel banded with steel bands at the breech over the charge chamber, the side straps, breech transom, &c., of the best forged charcoal wrought-iron, costing, for a single gun for test, $15,000, and an 8-inch breech-loading rifle, made *entirely* of the *best steel*, and costing, for a single gun for test, $24,000, the question of the relative merits of guns of the same caliber but made of different materials, upon my system of breech-loading, could be properly determined, and, by firing them up to 250 rounds each, much valuable data would be obtained, and a proper programme could be determined for continuing the firing up to 500 or 1,000 rounds each.

COL. THEODORE YATES'S STATEMENT.

Col. THEODORE YATES, United States Army:

Mr. Chairman, in presenting what I claim to be an improved projectile, it seems to me proper to first point out what I believe to be the defects of those in general use.

I ask your indulgence in this because, to my mind, this is the most important matter to be considered with reference to any system of gun construction.

I shall undertake to show that the destruction of guns heretofore has been due *mainly* to the faulty character of the projectiles used in them, and, until that is changed, we cannot depend upon the power or endurance of any gun, no matter how or of what material it may be made.

If the destruction of a gun is our object, we load it with a heavy charge, put a wedge in front of the shot, and apply the match. There is no doubt as to the result. With the present style of projectiles, our practice has been to put the wedge *behind the shot*, and, while the end is not so soon reached, it is no less certain.

With a sabot, or ring, on the base of a shot, we depend upon its being forced into the grooves of the gun by the power generated by the explosion of powder, and thus rotate the shot to which it is attached.

The force required to do this varies with the width and thickness of the ring, width and depth of the grooves, &c., and is an unknown quantity, beyond estimate or control.

Suppose we place a shot in a gun, and before the powder is introduced we drive wedges between the shot and ring until the latter is forced into the grooves of the gun. This is the least possible force exerted to burst or split the gun, before we are ready to move the shot.

I have never seen an estimate of the power required to force the ring on a 6-inch shot into the grooves of the gun.

Let me say it is 5,000 pounds per square inch. The ring on a six-inch shot has about 20 square inches of surface exposed to the action of the powder gases. Now we introduce powder enough to generate a force or pressure of 40,000 pounds to the square inch; 5,000 pounds to the square inch is enough to force the ring into the grooves of the gun, yet we add 35,000 pounds more pressure per square inch to split or burst the gun. Metal surfaces become welded together under such conditions; yet, under a pressure of 40,000 pounds per square inch, with an amount of friction of which we have no conception, we undertake to force the shot through 12 to 15 feet of the bore of a gun, and expect to give it effective force, power, velocity, after its delivery.

Why wonder that rings strip or break, that bands crumble, if the gun stands the strain under such conditions?

Cast iron has endured that *over four thousand times!!!* See Holley, page 886.

If we place a ball in a tube through which it will pass freely, and strike it a sharp blow, proportioned to its weight, we may send it to some distance, but if the tube be too small for the ball the same blow may not send it through; the force has been expended to wedge it fast. It is like trying to drive a plug into a hole too small for it. The plug must be compressed, the hole stretched, or something else must happen, and it generally does in a gun.

The expanded shot, or its sabot, is the plug, too big for the hole.

The purpose of the gun is to enable the powder to send the shot; the rifle is to give it direction *only*. Now, if we want power, *i. e.*, velocity, we ought not to obstruct the free and easy translation of the shot. We should rather remove all obstacles, and give the powder a chance to do its legitimate work—drive the shot, not tear the gun in pieces.

An evidence of power thus *worse than wasted* is found in the varying pressures, and *reduced velocity* with *higher pressures*, with the same charges of powder. (See Report Getty Board, p. 126, 157, &c.)

General Rodman appreciated the situation when he said:

> That it was useless to attempt to arrive at a correct measure of a rifled gun's endurance until a projectile was obtained which should be uniform and certain in its action.

The shock from the explosion of powder is almost instantaneous, and is in the nature of a blow; it occurs before the shot moves, always at the same place, and its effect upon the walls of a gun is like that of a mason's trowel upon a brick.

Many blows may be struck and no sign of fracture appear, but at the last one it falls apart.

Wax may be bent, rolled up, or stretched in any direction; yet one slight sharp blow will send it flying in pieces.

A slab of marble or plate of glass resting on a smooth, hard surface is easily fractured by a blow. See report Getty Board on wire guns: The tube was fractured by blows often repeated, and the wire body, having no longitudinal strength, soon pulled apart.

Again, the powder gases act upon the ring first, because it is lightest, and drive it forward into the body of the shot to wedge it fast or destroy the gun. (See Holley, page 102.)

Sometimes the ring breaks, and its parts are driven forward as wedges, or wedges are split off from the base of the projectile to either crush it or wedge it so as to offer greater resistance than does the entire breach of the gun, and the latter blows out. (See Holley, pages 17 and 886—Taylor.)

Action and reaction being alike, if we employ force enough to send a shot through 10 inches of iron plate, what must be the effect upon the gun under the most favorable conditions?

If, in addition to that force, we employ an equal, or greater force, to drive a plug or wedges into a gun, to tear its walls apart, what should we expect?

Is that giving a gun a fair trial?

Another evidence of power worse than wasted, is the heat imparted to a gun by the passage through its bore of a shot by its friction under such enormous pressure.

Tallow does not even melt in the chamber of a gun, though exposed directly to the action of the powder gases, and solder, melting at 212°, is barely affected.

"High power" in guns means great velocity of shot; great velocity demands large charges of powder, and that the least power shall be expended in overcoming friction and changing the figures of the shot.

If we build guns four times as strong as those we now have, and employ a powder charge increased in proportion, it seems to me that, with the system of projectiles in use, we shall not gain much. The strain upon the gun will be increased as is its strength, and we shall only reach our starting point. We drive the same wedges or plugs, with greater power, but the life of the gun, or its value, will not be increased.

In view of the ideas I have tried to express, the wonder to me is, not why *some* guns have failed, but rather why *all have not*.

So much for the evil effects upon the gun; now for the shot.

The first effect upon the ring, by expansion, is to raise up and center the base of the shot while its forward end rests upon the bottom of the bore; thus the axis of shot and gun are never coincident. The work of the ring is to rotate the shot, while the disposition of its body is to go straight out over and across lands. It starts with a wabble like a boy's top, and it deviates in the direction its nose takes at the instant of delivery. (See Report Getty Board, pp. 118, 119.)

Eccentricities in guns or projectiles are at the expense of reliability and power. Rifling seems at present to be a necessary evil. Let us keep it at the minimum.

Having tried to point out the evil, I submit my proposed remedy for it.

The body of my projectile is a plain cylinder of cast iron having a spiral groove about its circumference extending from end to end. The groove is filled with wire of suitable metal, or may be with a fibrous cord.

The cylinder is a fraction less in diameter than the bore of the gun. The wire or cord extends beyond the surface of the shot so far as to fill the grooves in the gun. The surfaces of shot and gun are never in contact; there is no lateral or bursting strain upon the gun, and the shot cannot become wedged. I can tell in pounds the force required to push the shot through the gun, and that will be constant *except* when the gun is weakened by being heated or expanded; it will be relieved because my shot does not expand.

If it takes 101 pounds of power to overcome the inertia of a 100-pound shot, the friction being a certain and constant quantity, we ought to be able to tell the effect upon shot and gun of the explosion of ten pounds of powder. My shot may be made very long and heavy, in proportion to cross-section, a matter of importance when power—punching effect—is demanded.

The conspicuous feature of my shot is its separate head of steel, so attached to the body that the two parts revolve separately and independently.

The head, or point, is in effect a cold chisel or punch, to cut its way, while the body is the power to drive it. It will not glance from a surface struck at an angle, as a ship's sides or deck. When the head strikes it becomes fast, while the body, revolving freely, performs its work as a pile-driver, without loss of power. Its length and weight, with small cross-section, makes a perfect punch of armor, and the form of its head overcomes the objection to conical or round pointed shot against armor. The latter break up, in the form of wedges, and lose their power. It is the reverse of splitting off wedges from the base, as before shown. (Holley, page 475.) The line of fracture is at about the same angle, and the length of the wedge is proportioned to the thickness of its base.

These views have been held and expressed by me during nearly twenty years past, and all observation and experience confirms me in them.

I venture to repeat that, in my opinion, the question of projectiles is the most important to be considered in connection with any system of gun construction.

THEO. YATES.

P. O. address, Milwaukee, Wis.; city address, No. 710 Eleventh street northwest.

[Exhibit to accompany Colonel Yates's statement, being an article from the Scientific American of May 18, 1867.]

THE BURSTING OF GUNS.

We have received a communication on this subject from a gentleman who has had excellent opportunities to investigate the matter, and has made many experiments to elucidate it. During the late war a large number of the projectiles used by the respective armies were ill adapted for service. Many of them broke in the gun on the shock of discharge, others burst outside the gun prematurely, while many did not burst as intended.

Cast iron is the metal usually employed for projectiles for guns. It is highly crystalline, and the size and character of the crystals depend upon the process of extraction of the iron from the ore, and on the amount and nature of foreign materials held in chemical or mechanical combination with the metal. Repeated meltings will change the size of the crystal; it is therefore necessary that the character of the metal should be well understood. Very soft material for projectiles upsets on the shock of concussion, and very hard metal is apt to fracture.

The mode of applying sabots, and the material of which they are made, are important. A hard sabot will transmit the shock of concussion to the shot itself, and tend to break off wedge-shaped portions or upset the base. Our correspondent speaks highly of the Thomas brand of iron, which has a tensile strength of 18,000 pounds per square inch, and the Hopkins' brand of cold blast, charcoal iron, having a tensile strength of 24,000 pounds to the square inch. He has never found any difficulty with either in practice.

Even sabots of papier maché, soft lead, or rubber, may, under certain conditions, cause the bursting of a gun by premature fracture, as when the gun has a gain twist if too fast, or the projectile is too heavy for the gun and the charge. Papier maché sabots, as usually manufactured in this country, contain potash combined with rosin as a binding material. The alkali absorbs and retains moisture, swelling the sabot.

If a gun be loaded, the projectile having a papier maché sabot, and not fired until several weeks have elapsed, the sabot would have time to absorb moisture and swell,

thus tending to burst the walls of the gun when acted on by the explosive force of the powder. A soft lead sabot has also a straining effect, especially when the gun is foul; it has no lubricating quality, but on the contrary retains grit, and is employed by the lapidary for this quality. Probably the bursting of rifled guns is often due to the wedging of the sabot in the projectile.

Fig. 1 is a sectional view of a 3-inch Parrott case shot. It will be seen that the sabot enters the base of the shot as a wedge. This is known as the Reed sabot. It is found in practice that this sabot has a tendency to break off pieces from the base of a projectile, which act as wedges, so that the projectile itself will take the grooves in the gun. Fig. 2 is a sectional view of a Parrott 20-pounder shell. It will be seen that the sabot does not enter the base as a wedge. But even this form does not save the shell.

Some believe that the unequal distribution of heat caused by the combustion of powder tends to the bursting of a gun. In Fig. 3 our correspondent shows a simple device for testing this question He styles it a "gun pyrometer." The engraving is a sectional view of a metallic cartridge capable of holding one pound of powder. A and B are slips of common tinned iron; on A is soldered a composition of tin and lead, which melts at 212°, and on B is a metal which fuses at 450°. The case, being charged with gunpowder, is placed in the piece and fired. On the removal of the cartridge case the metal fusible at 212° has melted and run down slightly, while that which melts at 450° has not changed. This has been repeatedly tried, and in no case were the slips of tinned iron warped or injured by the heat, or the metal on B injured. It would seem that the repeated experiments which have been made by our correspondent with this pyrometer tend to show that a very small amount of heat is communicated to the gun at each discharge by the combustion of the powder. No doubt considerable heat is generated in rifled ordnance by the friction of the sabot and projectile, particularly in rifled guns, and in some cases the friction is so severe that the edges of the lands crumble, and the projectile will consequently jam in the gun, straining it more or less; still, the wedging or upsetting of the bases of projectiles may prove more destructive or injurious to the gun than the premature bursting of a shell while in the gun.

Fig. 4 represents a shot which was fired with one of the wedge-shaped Reed sabots seen in Fig. 1. It is a 30-pounder projectile, and shows how the sabot broke off wedge-shaped fragments. Fig. 5 is another illustration. In this case the base is preserved, but there is the same wedge-like fractures. Fig. 6 is an 8-inch Parrott shell. It will be observed that the wedges are formed, but held in position. Fig. 7 is an 8-inch solid shot, the sabot of which was of hard gun-metal. The wedges extended up nearly the whole length of the cylindrical portion of the shot. Some of these hard-metal sabots were removed, and others of soft metal, composed of tin, lead, and copper, were substituted, and in no case were wedges formed. Fig. 8 represents a solid shot for an 8-inch Rodman. It has grooves to fit those in the gun. This shot requires no sabot. It will be seen that the condition of the grooves proves that they left the lands of the gun. On the fiftieth round the gun was burst.

The tendency of every shot in a rifled gun is to go straight forward; *i. e.*, leave the lands of the gun. Rotation of a shot is a forced motion, unnatural to the projectile, and it will be seen that with a high initial velocity the tendency of shot in such guns is to strain the walls. Then there is the strain from the upsetting or expansion of the base of shot, particularly of those using a sabot which acts as a wedge. Where the shot and gun both are of iron the friction on the lands of the rifling must be very great, and the action of the liberated gases and the direct line of the shot would tend to burst the gun; but the wedging of the fragments disengaged from the base of the shot must have an injurious effect on the gun. It seems as though the form and material of the sabot is a very important matter; and as it is easily seen that they affect the durability of the piece, greater attention to this matter should be given than that which it has heretofore received.

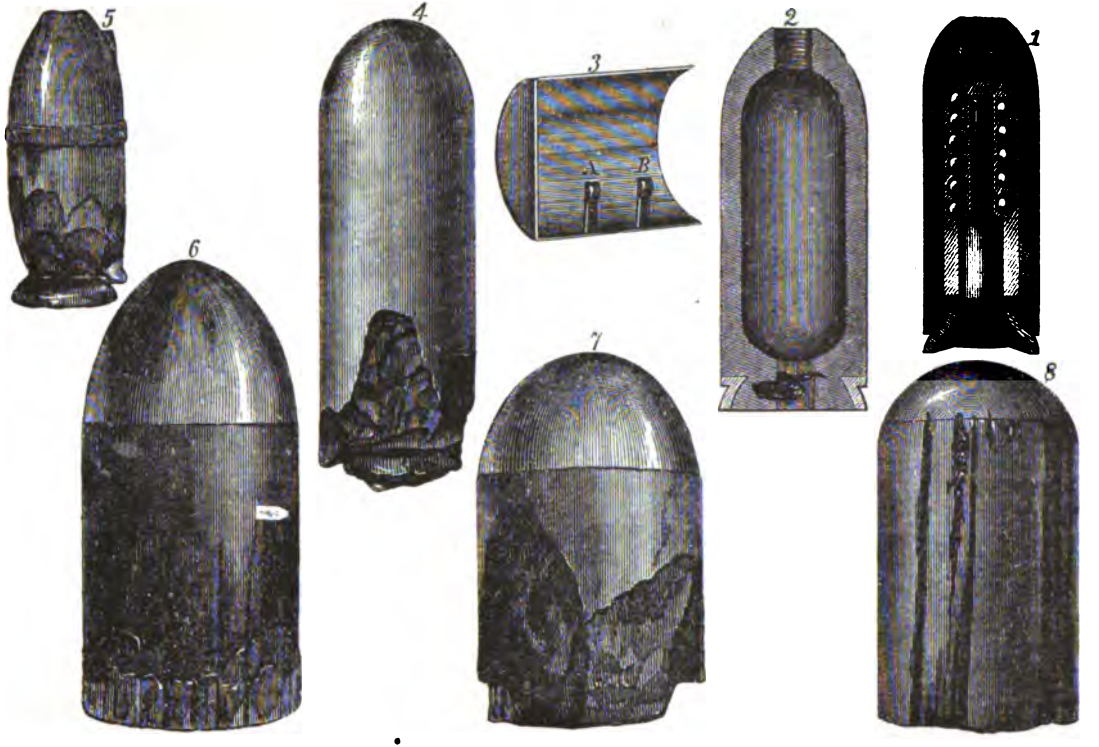
Colonel Yates exhibited a model, illustrating his proposal, and proceeded as follows:

Gentlemen, I assume it to be granted that rifled guns of the future are to be breech-loaders.

The model I exhibit is intended only to show the parts of my breech-closing device, their application and operation.

I have nothing to do with gun construction, my device being easily, safely, and cheaply applicable to guns of any form or constitution.

All I claim is, a shell or envelope for the entire breech of a gun, divided into two equal parts, or sections, in line of the axis of the gun, and a single lever, by means of which the sections are separated or brought together.



GUN PROJECTILES AND SABOTS.

S. REP'T 969, 2, 47.

A shoulder, or shoulders, are provided around the outer circumference of the gun, and corresponding shoulders, around the inner circumference of the shell, or sections, above described, the latter to abut against the former and support or sustain the whole shock of recoil.

The lever is attached by a pin to the under side of the breech of the gun. It has two slots, in which work pins, one on each of the two sections.

A slight movement of the lever to the right separates the two sections, each moving but little more than one-half of the diameter of the bore of the gun, and a reverse motion of the lever brings the sections together, closing the breech.

The above is substantially a full description of my breech-closing device, and, after inspection of the model, more need not be said.

Breech loading, or closing, is a simple mechanical problem.

The rear end of the bore of a gun is to be closed by such means as to offer greater resistance to the explosive effects of powder than does the shot in its front.

The strongest and simplest mode of doing this, other things being equal, is the best.

The breech part of any gun should, if possible, be the strongest.

I have high authority for saying that—

> What we now need is a gun that men can stand up to and not be afraid of. It is the men in front of the gun, not those in the rear, that we want to damage.

There is, *practically*, no limit to the possible strength of all the parts of my device. They are as few and simple as may be. The motions are all easy, natural, and the least possible. There is nothing to jam, stick fast, or blow out. There is nothing exposed to injury, nothing to be damaged by carelessness or neglect. (See Getty Board report, page 103.) Any man not skilled can operate it day or night, wet or dry. The gun is not weakened in any part by being cut; the bore is not shortened; no obstacle is offered to the introduction of the charge; and there is no gas check to be adjusted or renewed.

The gun complete *is no heavier than a muzzle-loader*, and *lighter than any other breech-loader of same length of bore.* It is no longer than any muzzle-loader, requires no more space in fort or ship, and does not need to be moved to be loaded. It makes no change in weight or proportions of a gun, and requires no alteration in carriages.

My system of breech closing affords complete relief from longitudinal strains upon the inner walls or tubes of guns, because the whole force or shock of recoil *comes upon the outside.*

This system offers extra security to persons, because in cases of disaster to the gun the shell sections would arrest and "save the pieces" that might else fly to the rear.

To illustrate the comparative strength of my device, I may say that the screw-plug in a 6-inch gun has a circumference of 20 inches. The thread on that, slotted, is ½ of 20 inches—10 inches—to sustain the pressure against the front end of the plug, about twenty-eight square inches.

The exterior diameter of the gun at the breech is 24 inches; circumference, 72 inches, which represents the bearing of my shell sections to sustain the same pressure at the base of the chamber, the difference being *over seven to one in my favor*, provided my sections are equal to the threads on the plug, and with the possibility, in my case *only*, of indefinite increase. "High power," the highest powers in a gun, can only be obtained by the use of *all the powder that can be used in it to ad-*

vantage, and the breech-closing device, *to be of any value*, must be more than equal to the greatest strain the gun can bear.

If we can have that, and a projectile that will enable us to use the power we obtain for its legitimate purpose, it may be discovered that we are now able to make pretty high power guns in any required number.

I ask that a 6-inch gun of cast iron may be made, under my direction, at the South Boston Iron Works, cast hollow, cooled from interior, and rifled in the manner deemed best for my purpose.

I ask that the shell sections, and parts included in my breech-loading device, may be made of steel, by the parties best qualified to do the work, the parts to be properly fitted to operate as in the model exhibited.

I also ask that 500 shot may be made, upon the plan of the model submitted, and fitted for use in the gun above described.

The gun, after proof, to be mounted and tested by firing the same quality and charge of powder now used in 6-inch guns until the 500 shot are exhausted, all proper records being kept, after which the gun may be subject to any desired test.

All contracts for gun and projectiles to be made by the honorable Secretary of War, and all tests made under direction of persons named by him, myself being present.

The work to be completed as early as practicable, and tests to be made as soon as possible thereafter.

I ask this for the following reasons:

I. My breech-closing device may be put to any required test in such guns.

II. It would afford speedy and cheap means of testing my shot, the rifling being adapted to its use.

III. It would enable us to test the value of cast iron for guns under what might be considered fair conditions, which many persons think has never been done.

IV. It might enable us to demonstrate that high power in guns may not depend upon larger caliber.

V. It is the cheapest means of arriving at the value of the theories advanced with reference to the cause of destruction of guns, because it would be in competition with guns of same caliber under existing conditions.

VI. If my device should fail, in any particular, the gun would remain intact, and the only loss would be the cost of the parts of my device.

For cost of drawings, patterns, and construction of first gun complete, I would say $5,000.

For making patterns, &c., and fabrication of 500 shot, same as model, to fit above gun, for mounting and testing gun and shot, $5,000, or so much thereof as may be necessary.

Now, Mr. Chairman, in conclusion, good faith to you demands that I should say my breech-closing device was submitted to the late Board on Ordnance, and was not recommended by them for test under the act of Congress approved March 3, 1881.

My patent was only issued on the 28th of June, 1881; did not reach me until after July 1, and the matter was sent to the Board on the 13th July. I was never present to explain it, answer questions, or meet objections, if any were raised. On the 27th July I was notified of the action of the Board in my case.

Simplicity of a device *often its great merit.* Something that can be comprehended at a glance sometimes fails to command the attention necessary to a proper understanding of its real worth.

I have tried to state clearly what I understand to be not only the

principal, but *all* the requirements of a perfect breech-closing system, and claim to have met them honestly and fairly.

In view of what I have shown I think that I am justified in saying that either the Board did not fully understand my proposition or did not give it the consideration its merits deserve.

I have offered some references to sustain my views, and could add many others.

If any statement I have made is questioned, I will produce ample evidence to support it.

If I have failed to make myself clearly understood in any particular, I ask an opportunity to do so.

STATEMENT OF J. R. HASKELL.

Mr. J. R. HASKELL. Mr. Chairman, I have the honor to appear before your committee, representing what is known as the "Lyman-Haskell accelerating or multicharge system in ordnance."

Until this invention was made all guns used only one charge of powder, and the shot only had the power of a single charge of powder imparted to it.

The only improvements made in late years in single-charge guns are in combinations of metals, in order to make guns stronger, in mechanical contrivances for breech-loading, and what is known as "chambering" or air-spacing. These mechanical improvements, together with the manufacture of a coarser and slower-burning powder, comprise about all the improvements in guns of the single-charge system.

The object accomplished in the "multicharge system" is the application of a greater propelling force or pressure on the rear of the shot without a corresponding increase of pressure on the walls of the gun—in other words, to give a much higher velocity to the shot with a less maximum pressure in the gun.

It is easy to make lines on paper and to annunciate theories in relation to ordnance, but these lines have to be applied or worked out in metal, and the theories have to be practically tested by the explosion of gunpowder, and frequently the theories explode with the powder. Guns have been constructed on theories which claimed they could not be burst, and yet they did burst, and the theories with them.

It has taken many years and the expenditure of a large amount of money to perfect the "multicharge system," and to produce a gun, shot, and gas-check harmonious in all the parts—a perfect working gun, certain in its action and perfect in all its parts. Several cannon had to be made, and many alterations made, before the whole was perfected, and the experiments have cost many thousands of dollars, besides the cost of the guns.

It has been demonstrated by many experiments that each additional charge of powder adds to the velocity or power of the shot, and that it is possible to keep increasing the velocity up to at least one-half of that of the velocity of the gas of gunpowder itself. This can be done with shot much longer than those now used in service, which are generally 2½ to 2.8 calibers long. By this system shot of 4 and 5 calibers long can be given a velocity of 3,000 feet per second, with a maximum pressure not exceeding 30,000 pounds per square inch in the gun.

The improvements in combinations of metals and gunpowder have about reached their limit. If the powder burns any slower the shot will

leave the muzzle before it is all burned, and this result has taken place in many instances in the records of experiments with large guns in Europe.

It is claimed by late reports from Italy that they have constructed armor which is invulnerable even to the 100-ton gun. It is therefore necessary, in order to increase the power of ordnance, to apply the "multicharge system," and obtain the force of successive charges of powder applied to the same shot.

With the "multicharge gun" all the advantage there is to be obtained by using slow-burning powder in the breech and air-spacing can be utilized, and after this has been applied and the shot has been started and the pressure is reduced by the expansion of the gas, then another charge of quicker-burning powder can be applied and the pressure brought up to the maximum again; this can be repeated until with the concentrated effect of the explosion of five charges of powder the shot is delivered with a power irresistible by any armor any ship can float.

The greatest penetration into wrought iron obtained by any gun in Europe is about 2 calibers (or twice the diameter of the shot). With one of our small guns, by the application of six successive charges of powder, a penetration of 10½ calibers was obtained. We do not claim that it is expedient or necessary to make guns with as great power as that; for if we did, a shot 9 inches in diameter would penetrate 7 feet 10½ inches of iron armor. It is, however, perfectly practicable to make a 9-inch gun that will penetrate 4 feet of iron armor.

As I before remarked, it has taken a great amount of money, time, and labor to perfect this system, and all this expenditure has been borne by private capital, furnished by the parties interested, without any aid from the government worth mentioning.

It is not to be expected that private capital and enterprise, unaided by the government, can entirely work out so great a problem as this. Enough has been done already to demonstrate the practical success of the system, and it is for the interest of the nation that aid should be extended to this enterprise by the government.

The owners were so satisfied with what has already been accomplished that they are now building, at their own expense, a 6-inch bore gun, with provisions for using five successive charges of powder, or, in all, 130 pounds of powder. It is expected that this gun will be completed early next spring. The system should be further developed, and a gun of 8 or 9 inches bore should be constructed by the government to carry out the experiment on a gun large enough and with sufficient power to penetrate more armor than any gun ever built. It is believed that a gun of that size would be as large as would be required.

The Congress of the United States has been frequently memorialized to construct guns, and put the cities and sea-coast defenses in condition to protect the great interests now practically defenseless.

In 1872 Congress passed an act appropriating $270,000 to build and test heavy rifled ordnance. A board of officers of the Army of different branches of the service were appointed under that act, to select such guns as in their judgment they should deem best. Inventors and others were invited to present their inventions and plans.

Forty guns were presented, and the Board selected nine out of the forty.

The money was to be expended in the order in which the guns were named. The "multicharge gun" was one of the guns selected, but it was the last one on the list, and the money was all expended before this gun was reached.

It is evident that the object of Congress in making this appropriation, and inviting the inventive talent of the country to submit their plans, was to find out something new and more powerful in ordnance, and to put this country in the lead in the power of its artillery.

The first favorites selected by the Board were guns which claimed to have new combinations of metals, or new ways of working metals to make guns stronger, or some mehcanical convenience in breech-loading.

Now, if all these guns (which had the money appropriated expended on them) had proven successful (which they did not), the armament of this country would not have been any superior to those of Europe, where they have several kinds of successful breech-loading cannon, and combinations of metals that are sufficiently strong to withstand the explosion of all the slow-burning powder that can be used to advantage in a single-charge gun. The guns made did not succeed; and if they had been perfectly successful, it would have been simply duplicating what had already been accomplished in Europe, giving this country no superiority.

It is not my purpose to complain of the action of that Board of Army officers. I know that it was composed of honorable and conscientious men, of educated and experienced practical military officers, and they discharged their duty in the interest of the government to the best of their ability in accordance with the evidence they had before them.

The education of the Army officers, and the practical experience they acquire, tends to make them conservative, and to test any system very thoroughly before they will approve it. They see so many failures of pet theories and inventions that this is a natural result. I believe, further, that it was well for the government that most of these experiments were made. If this government does not expect to be always in the rear, and to invite attack from even second or third rate powers, it will have to be much more enterprising than it has been for the past 17 years.

Since the Board of 1872 reported, and the experiments provided for were made (so far as the money went), other experiments have been made with the multicharge guns. Ordnance officers, Engineer and Artillery officers, have given this "multicharge system" a thorough examination, have seen many experiments; and eminent officers of different branches of the service have been to Reading, Pa., and inspected the gun now making at the Scott Foundry, the machinery and tools used in its construction, the metals, and workmanship.

After a long examination and thorough knowledge of all the plans and experiments already made, these eminent officers are firm believers in the final success of the "multicharge" over the single-charge system.

I believe that the Ordnance officers of the Army are conscientious, able men, of large experience, and that they act for the best interests of the government they serve, and to their judgment I am willing to submit these guns for actual tests.

Congress has however taken action again, and by the act approved March 3, 1881, a Board composed of Engineer, Ordnance, and Artillery officers met to make another selection from guns submitted by inventors and others. Of this Board General Getty was the president. Many more guns were presented to this Board than to the Board of 1872. The Getty Board made their report in 1882. There were ten guns recommended for construction and test. By reference to the report published by the Senate. Ex. Doc. No. 178, Forty-seventh Congress, first session, it will be seen that the "Lyman-Haskell multicharge gun" is No 1—this time it heads the list.

In order to settle all questions in regard to the "multicharge system," all should not be left to the moderate sized gun the owners are now building, but a gun should be built using a shot more than double the weight of those to be used in the gun now making at Reading, Pa.

I therefore ask your honorable committee to recommend the appropriation of $100,000 to pay for constructing a gun of 8 inches bore, on the "Lyman-Haskell accelerating or multicharge system."

In the language of a distinguished officer—who was formerly an officer of Engineers, and afterwards a distinguished general commanding one of the great armies during the war—

> This gun, in my opinion, will not only revolutionize all the artillery but also all the navies' and fortifications of the world.

This officer gave this opinion after spending two weeks in a thorough examination of the subject, with a detailed history of the whole course of experiments, and the improvements made in the system before him.

This application is simply to ask the government to pay for making one of these large powerful guns for its own use and benefit.

Unless this appropriation is made at the present session, a year and a half will be wasted before one of these large guns can be commenced and this great question settled. A commencement in arming our defenseless coast cannot be made until this question of superiority is settled.

Out of money appropriated by Congress, $70,000 was expended in making one gun, which was simply a new arrangement of cast iron in making a gun; over $120,000 was expended on another gun, which was simply a new combination of metals; $100,000 on another, which was simply a new manner of forging, &c. Neither of these guns succeeded, and it is time, now, that a system should be tried, which if successful will put this country in the front rank so far as ordnance is concerned.

In making the first large gun the cost will be much greater than for subsequent guns on account of the cost of machinery and tools, called the "plant."

I have the honor herewith to submit the drawings of the proposed 8-inch "Lyman-Haskell multicharge gun."

Senator HAMPTON. What is the cost of making a 6-inch gun on your plan?

Mr. HASKELL. I have not got at the exact cost of a 6-inch gun.

Senator HAMPTON. What is the weight of the projectile?

Mr. HASKELL. One hundred and fifty pounds.

Senator HAMPTON. How long?

Mr. HASKELL. Four calibers long.

Senator HAMPTON. How are the successive charges ignited?

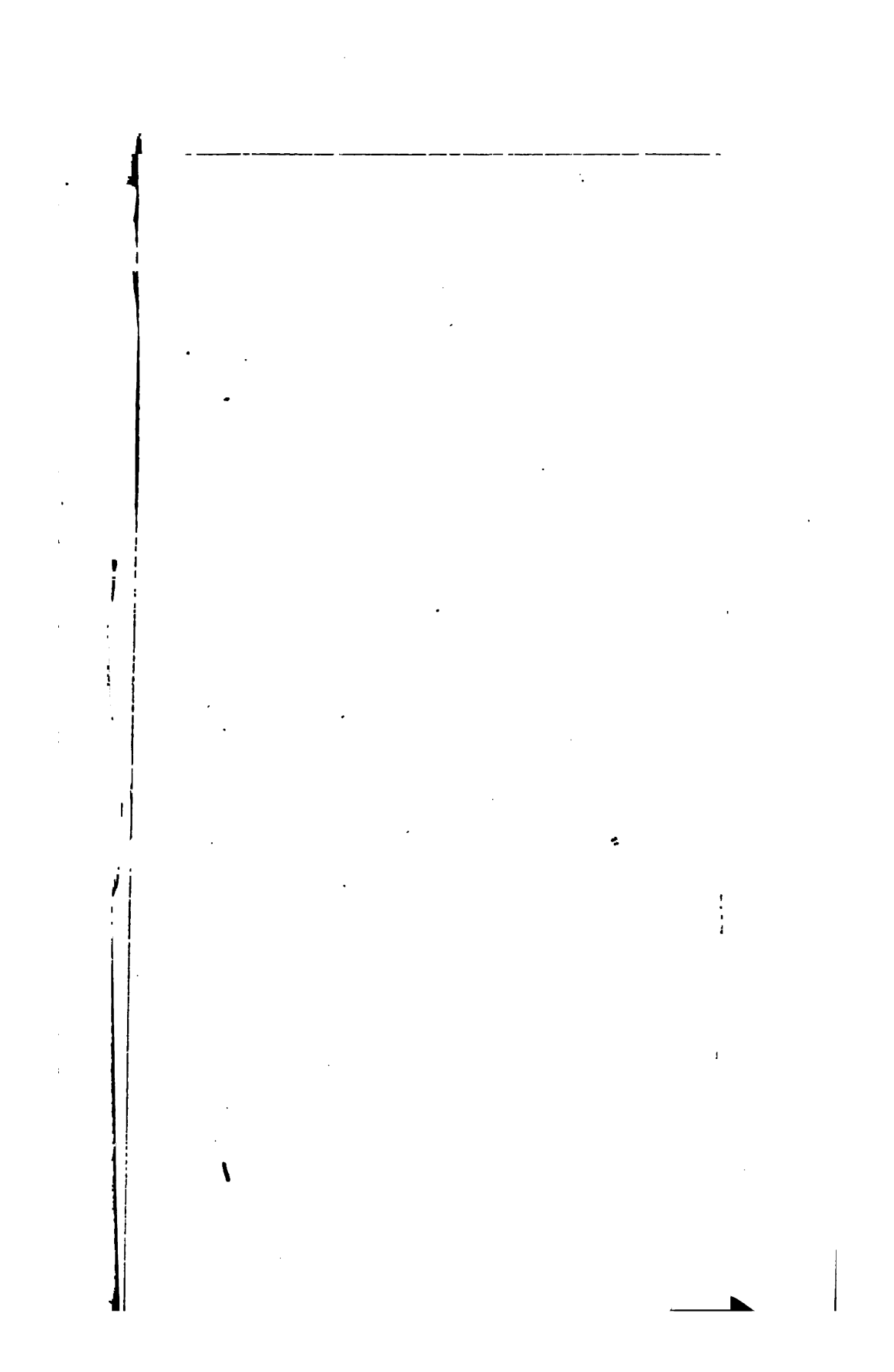
Mr. HASKELL When the shot passes this point of intersection [indicating] the powder runs down and ignites the charge.

Senator HAMPTON. In the test you have made have any of those charges exploded before the ball passed?

Mr. HASKELL. In some tests that were made by the late Alvin C. Stimers, chief engineer of the Navy, he made no provision for stopping the gas; he did not think it was necessary. I told him it was, and he did have that happen. It has never happened in the experiments I have made. I have made thousands of experiments.

Senator HAMPTON. How do you stop the gas?

Mr. HASKELL. By a peculiar gas-check I have, which experience has shown to work properly.



Senator HAMPTON. What would be the weight of a 9-inch gun?

Mr. HASKELL. One hundred thousand pounds. Our gun weighs about the same as any other that uses the same amount of powder.

Senator ROLLINS. That uses the same amount of powder in the one charge that you would use in five?

Mr. HASKELL. Yes, sir.

The CHAIRMAN. You spoke of a gun nearly completed by you now?

Mr. HASKELL. Yes, sir; I think it will be completed about the time Congress adjourns.

The CHAIRMAN. Will you present a plan of your gun?

Mr. HASKELL. Yes, sir; this is it.

Mr. HASKELL subsequently sent to the committee the following communication:

WASHINGTON, D. C., *January* 13, 1883.

SIR: The proposed 8-inch "Lyman-Haskell multicharge gun" is to be built of charcoal cast iron and steel combined. The outside of the gun to be of cast iron, the pockets to be cut in cast steel, and the main bore of the gun is lined with a cast steel tube. The pockets and the bore, therefore, are continuously lined with steel, as shown in the drawings in the report of the Getty Board.

Yours, truly,

J. R. HASKELL,
83 *Broadway, New York.*

Hon. JOHN A. LOGAN,
Chairman Committee on Ordnance.

JANUARY 20, 1883.

The chairman laid before the committee the following letter:

Letter of J. R. Haskell.

[Office of J. R. Haskell, president Multicharge Gun Company, 83 Cedar Street.]

NEW YORK, *January* 17, 1883.

SIR: I have the honor to submit to you, and the committee, a few facts in relation to the multicharge gun. I asked your committee to recommend an appropriation of $100,000, or so much thereof as would be required, to build an 8-inch gun for the government. A detailed statement of some of the experiments made will be found in the pamphlet I submitted, and also in the report of the Getty Board, pages 116 to 122. I desire to give in addition a comparison of the charges of powder in the Armstrong (English) single-charge gun, and the multicharge, both being 8 inches bore. The Armstrong gun uses from 85 to 95 pounds of slow-burning powder and a shot weighing 182 pounds. The 8-inch multicharge gun would use about 40 to 45 pounds of the same powder in the breech, and from 75 to 80 pounds of powder in each of the four pockets; the powder in the pockets being less in weight than that used in the breech of the Armstrong gun, but of a quicker-burning powder, and applied after the inertia of the shot has been overcome and it is already in motion. The multicharge gun would therefore have the power given by about 350 pounds of powder, with less maximum pressure in the gun, while the Armstrong has only the power due to 85 to 95 pounds of powder. The shot of the multicharge gun will weigh more than double as much as the shot of the Armstrong gun, as the following table will show:

	Pounds.
Armstrong 8-inch shot, 2½ calibers long	182
8-inch multicharge gun, shot 3 calibers long	260
8-inch multicharge gun, shot 4 calibers long	364
8-inch multicharge gun, shot 5 calibers long	468

The weight of the 8-inch multicharge gun is about 50 tons.

A 9-inch bore multicharge gun would use the following charges of powder:

	Pounds.
Breech charge, 60 to 70 pounds	70
Four pockets, each 100 pounds	400
Total	470

Or more powder than the Armstrong 100-ton gun, and the weight of the gun would be about 77,000 pounds less than that of the Armstrong gun.

Respectfully submitted to the committee.

Your obedient servant,

J. R. HASKELL.

Hon. JOHN A. LOGAN,
Chairman Special Committee on Ordnance.

GENERAL S. V. BENÉT, CHIEF OF ORDNANCE, U. S. A.

The CHAIRMAN. Please state to the committee your views in reference to heavy ordnance and projectiles, and the different tests, and tell us what you think ought to be done.

General BENÉT. The present condition of our armament is such, and the facilities for producing in this country the best material for heavy guns are as yet so limited and inadequate, that the whole subject demands the gravest consideration from Congress. I have given the matter much careful study, and I will indicate my own views as regards what course we should pursue. From what is stated by the engineers of the Army, we want probably 4,000 guns for the armament of the sea-coast. Of course, we possess many guns, simple cast-iron smooth-bores, most of them, with a few rifled guns on the Parrott system that are not considered very good. The point, I think, we have to consider at present is what should be done towards arming the whole coast without procuring such a large number of new guns. In arming the coast we cannot expect to make, even if we could utilize, 4,000 high-power guns as they are recognized now in the world, because I do not believe Congress would appropriate the necessary money, and it would take 20 years to do it.

It seems to me that what is best to be done is, first, to see whether we cannot utilize something that we have on hand. The whole world has thrown aside cast iron, used by itself, as a material for heavy rifled cannon, and, I think, with complete justification. I still think, however, that for moderate-sized guns cast iron in union with some stronger metal, as steel or wrought iron, can be utilized. I think we have proved it to a very considerable extent.

Can we make use of the guns on hand in our forts now? I think that a very important question, because we ought to be doing something, and, if we can commence here, it is not only a step in the right direction, but it will admit of our immediate action. Our defenseless sea-coasts should be armed. We have been doing as much as possible with the limited means at our disposal, and in the last few years have taken some of our 10-inch smooth-bore guns (Rodman's guns), of which we had about 1,200, and we have converted over 100 into 8-inch rifles.

We have followed the system that was used in England to a very considerable extent. I think England has about 2,000 of those guns now. They are small, but they are useful. We have converted, as I say, 100, making 10-inch smooth-bores into 8-inch rifles.

That conversion is made by taking the cast-iron gun and putting a wrought-iron coiled tube in it. The gun weighs about 16,000 pounds. As a smooth-bore it would fire a round shot weighing about 130 pounds with about 16 pounds of powder. When we make it an 8-inch rifle we use a shot weighing 180 pounds and 35 pounds of powder; that is the normal condition.

A good deal has been said in the papers in regard to our failure with these guns, &c. That is all wrong. We have tried these guns effectually, and they show not a single failure; but, on the contrary, have proved to be admirably good guns, and can be converted comparatively cheap.

I have a statement here, which I will submit to the committee, in which it is shown that we have fired three of these guns between 650 and 820 rounds each with 35 pounds of powder and 180-pound shot, and those guns are good now.

Another converted gun, which was chambered so as to give it a larger capacity for gunpowder, has been fired 170 rounds with 55 pounds of powder, instead of 35, and with a shot weighing 180 pounds, and the gun is perfectly good. None of these guns have ever failed or shown any signs of failure. This is the statement to which I refer:

Summary statement of the number of rounds fired (proof rounds excluded) from 8-inch converted muzzle-loading rifles, with mean weights of powder charges and projectiles, pressures, velocities, and penetrations.

Gun.	Number of rounds fired.	Mean weight of powder charge.	Mean weight of projectile.	Mean pressure.	Mean velocity at muzzle.	Penetration in iron at—	
						Muzzle.	1,000 yards.
		Pounds.	*Pounds.*	*Pounds.*	*Ft. per sec.*	*Inches.*	*Inches.*
8-inch converted rifle, No. 1	817	35	181.5	37,450	1,440	10.26	8.5
8-inch converted rifle, No. 5	648	35	181.5	23,570	1,276	8.82	7.45
8-inch converted rifle, No. 7, B. I.	381	35	181.5	32,000	1,391	9.82	8.18
8-inch converted rifle, No. 1, B. I.	783	35	181.8	26,462	1,279	8.84	7.47
8-inch converted rifle, No. 28, chambered	172	55	179.8	37,809	1,641	12.00	9.86
8-inch converted rifle, No. 29, B. I.	53	35	181.0	34,359	1,419	10.03	8.35
8-inch converted rifle, No. 38	184	35	181.0	36,529	1,425	10.09	8.40

So much as to the endurance of these small converted guns. Now as to their power.

Having some wrought-iron plates that were purchased by the engineers a few years ago for experiments, and turned over to us, I thought I would try these little guns at wrought iron to see whether they would do the work we had a right to expect in view of experience abroad, and I have a statement here showing the results obtained. The targets were placed about 100 yards from the muzzle, and the charge of powder reduced so that the effect of the shot at 100 yards would be the same that it would be with the full charge at a thousand yards. The gun with 27 pounds of powder penetrated about 9½ inches of iron under an angle of 24°, and 10½ inches under direct fire. I presume it would have fully perforated 6 inches of iron. These plates being 4 inches thick, we had to put them together. These results show that the gun at 1,000 yards can do considerable damage.

I have also a statement which I will submit, showing the armor on the vessels of the world. We find that there are only fifty vessels in the world that carry more than 10 inches of armor. There are some two or three hundred that carry between 5 and 10 inches, but the large majority actually carry less than 5 inches. Thus the large bulk of the navies of the world are unarmored vessels, wooden vessels, and therefore this little gun could hold its own against three-fourths of the navies of the world. It amounts to that. It is only the very heavily armored vessels, of which there are but fifty, excepting a few coast-defense vessels, that the gun cannot penetrate. The largest number of the armored vessels of the world carry but 4½ or 5 inches of armor, and this gun will penetrate that thickness of metal. This is the statement:

ENGLAND.

[Twenty vessels.]

Name of vessel.	Thickness of armor.	Draught.	Armament.
	Inches.	*Feet.*	
Agamemnon	18	24	5 12.5-inch.
Ajax	18	24	5 12.5-inch.
Colossus	18	26.25	4 12-inch.
Devastation	12	27.5	4 12-inch.
Dreadnaught	14	26.75	4 12.5-inch.
Inflexible	24	25.5	4 16-inch.
Majestic	18	26.25	4 12-inch.
Monarch	10	26	2 9-inch; 1 7-inch.
Neptune	12	25	4 12.5-inch.
Thunderer	12	27	4 12.5-inch.
Conqueror	12	24	2 12-inch.
Alexandra	12	26.5	10 10-inch; 2 11-inch.
Belleisle	12	19.75	4 12-inch.
Nelson	10	24.75	4 10-inch; 8 9-inch.
Northampton	10	24.75	4 10 inch; 8 9-inch.
Orion	12	19.75	4 12-inch.
Rupert	12	24	2 10-inch; 2 64-pounders.
Superb	12	26	16 10-inch.
Sultan	10	27.5	8 10-inch; 4 9 inch.
Téméraire	11	27	4 11-inch; 4 10-inch.

Thirty vessels with armor less than 10 inches thick; eighty-one unarmored vessels.

FRANCE.

[Eight vessels.]

	Inches.	*Feet.*	
Amiral Baudin	21.6	26	3 100-ton; 12 5.5-inch.
Amiral Duperré	21.6	26.75	4 13.5-inch.
Devastation	15	25	4 13.5-inch; 2 10.5-inch; 6 5.5-inch.
Formidable	21.6	26	3 100-ton; 12 5.5-inch.
Hoche	13.75	27	3 13.5-inch; 18 5.5-inch.
Magenta	13.75	27	3 13.5-inch; 18 5.5-inch.
Marceau	13.75	27	3 13.5-inch; 18 5.5-inch.
Neptune	13.75	27	3 13.5-inch; 18 5.5-inch.

Ten coast-defense vessels with armor more than 10 inches thick; twenty-five vessels with armor less than 10 inches thick; forty-six unarmored vessels.

GERMANY.

[Nine vessels.]

König Wilhelm	12	26.5	18 9.5-inch; 5 8.25-inch.
Kaiser	11	24.5	8 10.5-inch; 1 8.25-inch.
Deutschland	11	24.5	8 10 5-inch; 1 8.25-inch.
Sachsen	10	19.75	1 12-inch; 4 10.25-inch.
Baiern	10	19.75	1 12-inch; 4 10.25-inch.
Würtemburg	10	19.75	1 12-inch; 4 10.25-inch.
Baden	10	19.75	1 12-inch; 4 10.25-inch.
Preussen	10.5	24.5	4 10.5-inch; 2 6.7-inch; 4 3-inch.
Friedrich	10.5	24.5	4 10.5-inch; 2 6.7-inch; 4 3-inch.

Four vessels with armor less than 10 inches thick; twelve monitors with 8 inches of armor; 33 unarmored vessels.

ITALY.

[Four vessels.]

Name of vessel.	Thickness of armor.	Draught.	Armament.
	Inches.	*Feet.*	
Italia	29.5	31	4 17.7-inch; 18 smaller.
Lepanto	29.5	31	4 17.7-inch; 18 smaller.
Duilio	21.5	26.75	4 17.7-inch.
Dandolo	21.5	26.75	4 17.7-inch.

Twelve vessels with armor less than 10 inches thick; eighteen unarmored vessels.

BRAZIL.

[Two vessels.]

Solimoës	12	11.5	4 10-inch.
Javari	12	11.5	4 10-inch.

16 vessels with armor 4.5 inches thich; 6 vessels unarmored.

RUSSIA.

[One vessel.]

Peter the Great	17	24.5	4 12-inch.

Eighteen vessels with armor less than 10 inches thick: twenty-eight unarmored vessels.

AUSTRIA.

[Two vessels.]

Tegetthoff	14.5	25.	6 11-inch; 8 smaller.
Custozza	11.75	24.5	8 10.25-inch; 8 smaller.

Eleven vessels with armor less than 10 inches thick; twenty-two unarmored vessels.

SPAIN.

Eleven vessels with armor less than 10 inches thick; eight unarmored vessels.

JAPAN.

Four vessels with armor less than 10 inches thick; five unarmored vessels.

CHILI.

Three vessels with armor less than 10 inches thick: four unarmored vessels.

TURKEY.

[Two vessels.]

Name of vessel.	Thickness of armor.	Draught.	Armament.
	Inches.	*Feet.*	
Messudijé	12.	26.	12 9.75-inch; 3 7 inch.
Nussratijé	12.	24.5	10 9-inch; 2 7 inch.

Sixteen vessels with armor less than 10 inches thick.

SWEDEN AND NORWAY.

Sixteen monitors: Turrets more than 10 inches thick; at water line, less than 5 inches thick
Two monitors: Turrets less than 10 inches thick; at water-line, less than 5 inches thick.
Seventeen unarmored vessels.

RECAPITULATION.

Country.	Number of vessels having armor.		Unarmored.	Remarks.
	More than 10 inches thick.	Less than 10 inches thick.		
England	20	30	81	
France	*10 8	25	46	* Coast-defense vessels.
Germany	9	†12 4	33	† Monitors.
Italy	4	12	18	
Brazil	2	16	6	
Russia	1	18	28	
Austria	2	11	22	
Spain		11	8	
Japan		4	5	
Chili		3	4	
Turkey	2	16		
Sweden and Norway	‡16	‡2	17	‡ Thickness of turret at water-line less than five inches thick.
Argentine Republic		3	6	
China			23	
Denmark	1	8	8	
Greece		2	3	
Holland		14	24	
Portugal	1		9	
Total	76	191	341	
Or, deducting monitors and coast-defense vessels	26	14		
Total	50	177	341	

From Brassey's "The British Navy"; Very's "Navies of the World"; King's "The War Ships and Navies of the World."

The engineers called on me not long ago (and I have been making some experiments in that direction, not yet completed), for guns to protect their torpedo fields; when they plant their torpedoes they require something to protect them against small craft. Of course, a heavy armored vessel is not going to venture to take up or explode torpedoes; small craft will be sent out to do that work. Their idea was that we might utilize these 10-inch smooth-bore guns, of which we have a large number, for covering the entire field with a continuous fire of case and canister shot. We find from the trials we have made that the canister shot fired from the 10-inch gun will penetrate about five-eighths of an inch of steel, which is about the thickness of the sides of the small torpedo launches.

We can use canister shot in the 8-inch converted rifle just as well as in the 10-inch smooth-bore, and the rifle is a much more useful weapon for many other purposes; so in every respect this would be a much better gun for the protection of torpedo fields.

Then there are many points of secondary importance, as, for instance, at harbors where the depth of water does not admit of the entrance of a heavy iron-clad, where these guns would perform admirably the work of defense, as they are quite competent to cope with a moderate thickness of armor. Therefore, in my opinion, we ought to go on and convert these guns. They will at least tide us over until we can get something better in the shape of rifled cannon, and will always be useful for secondary positions.

The CHAIRMAN. How many of these 10-inch guns have we?

General BENÉT. We had 1,200; we have converted a little over 100; so that we have about 1,100 on hand. We have another gun that we can still use with very excellent effect—the 15-inch smooth-bore gun.

It is a muzzle-loader. It is too short in the bore to convert into a very effective rifle, as has been done with the 10-inch smooth-bore. The round shot for the gun weighs 450 pounds. At the time these guns were made the powder charge was only 45 or 50 pounds. Now we use 100 to 125 pounds of powder. Though these guns would penetrate, at a thousand yards, not more than, say, 6 to 8 inches of iron, still their smashing effect is very great, and they can be utilized, and ought all to be mounted; many of them are already mounted.

There are about 300 of these guns on hand. There are nearly enough carriages on hand to mount them, but many of them require modification to meet the recoil due to the increased charge, to facilitate maneuver, and in some cases to adapt them to the increased height of the parapets.

I recommend that they be placed in a serviceable condition by suitably modifying their carriages and mounting all those not mounted; and I also recommend that the work of converting the 10-inch smooth-bore guns be continued so as to procure, say, 300 8-inch rifles.

We will thus obtain, in an economical manner, an armament that will admirably serve several purposes:

1st. To defend secondary positions in our principal harbors.

2d. To defend our smaller seaports.

3d. To protect our torpedo fields from being disturbed by the enemy.

The question now comes, what are we to do towards getting guns that will be able to hold their own against the powerful guns of foreign navies and to penetrate the armor of heavy iron-clads? Steel in some form must be the metal of which these guns are made, and as our experience is so limited in the manufacture of this metal for gun-construction, we should commence *immediately* with guns of smaller caliber, 6 and 8 inch, that are within the present capabilities of our foundries and factories, and work up to those heavier guns that are a necessity to our coast defense. I cannot urge this point too strongly; and that it may be very plain what we are to do, I have taken the liberty to insert in the fortification appropriation bill as it passed the House of Representatives the words "and experimental guns of steel and steel wire-wound."

I take it for granted that Congress would not be willing for us to buy our guns from Krupp, in Germany, or from Armstrong, in England, but would require that we make them ourselves. It will be years before we are able to produce guns of as large caliber and in the numbers we require. We should begin the work at once, in order that there may be no delay in its development. While we are working up to this point in *steel*, what should we do to provide an armament that, while not furnishing all to be desired, will yet be better than anything we have at present, and when the steel day comes, good even then? I repeat that we *must* keep an eye on *steel*, and keep on striving toward an armament of that metal; but, in the mean time, we can manufacture cast-iron guns, strengthened in some way with steel. We can take a cast-iron body and hoop it with steel or, better still, wrap it with steel wire, and thus obtain guns of very considerable power, particularly on the latter plan. The advisability of making such guns was recognized by the Getty Board, in whose recommendations I fully concur.

It is not considered that such a gun as that will be what we call a high-power gun, but it will do a great deal of very heavy work. That is, I should say it would do work of this kind. While our 8-inch converted gun would penetrate about eight inches of iron, say a caliber, I should say that a cast-iron gun either wrapped with wire or banded with steel, and lined perhaps with a short steel tube, would, with our new powder, penetrate a caliber and a half of iron, or 12 inches, but a

gun of the same caliber, of *steel*, what we call a high-power gun, would penetrate at least two calibers—that would be 16 inches of iron. That is, in general terms, I think, about their relative power.

In making a cast-iron gun and wrapping it with wire, and applying a breech arrangement similar to the French, all the work could be done in this country. Our founders can do that; they can make cast iron better than any in the world. As to the wire, we can make the wire and have enough skill in this country to wrap it; we would strengthen it probably by soldering with soft solder so as to keep it from moving; and there would be no difficulty in getting the block for the breech-screw or the tube, because they are comparatively small pieces of steel. I think that, probably, would be a very good move, because it is something we know we can do in this country. It would give us what we call a gun of moderate power. It is not a high-power gun, but still a fairly strong gun, and capable of doing good service.

To return to the matter of steel guns. If Congress were to go into their fabrication, I should begin by trying to make two 8-inch guns. I presume that to make one with bands of steel and another wrapped around with wire, would probably take me at least two years. If we succeeded we could go on making steel guns of that caliber, and at the same time take a step further and try a 10-inch gun; that would take a year or two more; then if we were successful we could go to a 12-inch gun, which of course would require increased plant and heavier hammers. I should say, if we had the means of going on, that in the course of eight or ten years we ought to have the requisite plant in this country to make guns of any size we might require; but we have not got it now; we have barely got heavy enough hammers for the smaller caliber of guns, such as 6 and 8 inch, and at several of our best establishments a steel ingot cast at one place has to be sent to another place to be forged; steel-making, of a quality suitable for guns, has not yet progressed beyond the experimental stage.

As to giving an order for and giving the money to make fifty steel guns, we cannot do it. We have to commence at the very beginning and learn how to make them. Our people here have got to learn how to produce the metal.

I saw a statement two or three years ago that Krupp was putting up a hammer in his works that would cost 5,000,000 francs, and I have been informed respecting the hammer put up at Woolwich some three or four years ago that merely the foundation and the substructure for the hammer cost $250,000. So you see this gun-steel-making is a big business. The plant is heavy. You cannot probably get parties to go into it unless they can see something ahead from which they can realize.

The question of wire has come into prominence very recently, and it is a very important matter. As far as we know, the wrapping of wire around guns was an invention in this country of Dr. Woodbridge. You will find that many of the best inventions of the world are American, especially in gun-construction. We made a wire gun in 1872, and the Getty Board tried it and broke it. That was the first made, and very likely it can be improved upon. Recently, experiments have been made in England in this direction. Sir William Armstrong has constructed two wire-wrapped steel guns, and he wrote me a letter, giving some information in respect to them, about a year ago. He stated he had made two guns, one a 6 inch and one a 10¼-inch gun, and that the 10¼-inch gun fired a shot of 500 pounds weight with a charge of 300 pounds of powder. The gun consisted of a steel tube wrapped with wire, or what he called steel ribbon, which is nothing but a flat wire probably two-tenths of an inch wide and half a tenth thick.

With a shot of 500 pounds weight and a powder charge of 300 pounds, and an initial velocity of 2,100 odd feet, I suppose that the projectiles would have penetrated 23 inches of iron. He informed me that he had sold this gun to the British Government, and that they intended to make experiments at Shoeburyness, where it has been fired, but not to any very great extent, the difficulty it seems being that they are trying to get powder that will best suit the gun.

Whatever may be the the views and opinions of individuals in respect to the material for heavy guns, we know that in Europe they have spent millions of dollars where we have spent hundreds, in working out this problem, and we find that they are all coming to steel as the best metal. This morning I saw it stated that in Russia a 6-inch steel gun went to pieces on trial. I suppose that will happen sometimes; it cannot be helped.

We cannot make heavy steel guns in this country at present; therefore the steel manufacturers ought to be encouraged in some way. The Navy has already made a commencement in the manufacture of steel guns. They have produced a 6-inch steel, though I believe they experienced a good deal of trouble in procuring a satisfactory material, which, together with the unsatisfactory manner in which the work of manufacture was done, greatly delayed the completion of the gun. Now they are trying to get the steel to make a 6 and 8 inch gun. This type of gun is made of a tube of steel, on which is put a jacket, as it is called, and then steel bands are put on outside of all. The facilities for making steel in this country are very limited, necessarily. There has been no demand for steel in masses of the size and quality demanded for gun construction. Now, however, when it seems that our steel works are rather short of work on account of the accumulation of steel rails in the market, or the money being out, they have been turning their attention to guns and are making practical inquiries as to the qualities of gun steel, and some of the very large steel works, possessing the capital, have expressed a willingness to invest it in plant if there is any prospect ahead of reimbursement in the way of orders from the government for guns.

The CHAIRMAN. Where do you convert guns?

General BENÉT. The government has no works of its own. From the foundation of the government we have had Congressional committees, I think half a dozen times or more, in regard to the establishment of a national foundry in order to make guns. In every case the committee reported favorably, and that was the end of it. I suppose every State wanted the foundry; every State had iron in it, and local interests interfered; at any rate no action was ever taken, and therefore we never got a national foundry, and work for the government has been done at private establishments. The foundries that the government has employed for more than fifty years are a foundry in South Boston, known as the South Boston Iron Company, and another foundry at Cold Spring, N. Y., near West Point, and known as the West Point Foundry. There have been other foundries, but they have gone out of existence. There was one at the South, the Tredegar Works, at Richmond, Va. Work was done there years ago. Then there was the Fort Pitt Foundry at Pittsburgh. That has gone out of existence. It was quite a large establishment, and did a great deal of work for the government. There was also a foundry at Reading, Pa., where we had some guns made during the war, and the Lyman-Haskell multicharge gun is being made there now. At present the only two foundries that are at all equipped for work are the foundries at Boston and Cold Spring. Of course they do not make steel.

The CHAIRMAN. When you speak about changing guns, do you mean to change them to breech-loading guns?

General BENÉT. No, not those 8-inch guns. I would not make them breech-loaders, but merely change them by putting the tube in.

The CHAIRMAN. Are they to be rifled?

General BENÉT. Yes, make them rifles; and then use 35 pounds of powder and about 180-pound shot, and these guns have stood any quantity of firing.

The CHAIRMAN. You prefer the tube, as I understand you, not only as strengthening the gun but as giving it more power to use powder?

General BENÉT. Necessarily by putting in the tube you make it stronger; there is no question about that. While a cast-iron gun may do very well at one time, the metal is very treacherous, and while you may make a cast-iron gun to-day and you may fire it forever without bursting it, you do not know but that the next gun you make under exactly the same conditions will go to pieces after a very few rounds. Therefore the world has thrown it aside. Even when strengthened with steel it has not been found to answer for very large guns. I will give you an example:

The Italian Government, which is a very progressive one on the gun question, and has some of the ablest ordnance officers in the world, worked this question of cast-iron to a practical solution when it made its 100-ton gun, which was a cast-iron body, as we call it, strengthened with three rows of steel hoops. The amount of steel in that gun was more than half the weight of the entire gun. The gun was fired more than 100 rounds and endured the proof very well, still they were afraid to run up the pressures in the bore and thus secure such a velocity as would place the gun on a par with the Armstrong 100-ton gun. So the artillery committee decided that, while the gun had done very well, it was not advisable to make any more guns like it. The power attainable with contemporary guns pointed to steel as the only metal for very heavy guns.

The first 100-ton guns, supplied the Italian Government, by Sir Wm. Armstrong, were made of wrought-iron coils put on over a steel tube, but now the Armstrong guns are being made principally of steel. The last 100-ton gun made by Armstrong is a breech-loader; the first ones were muzzle-loaders. That was the gun they tried recently at some armor plates which they could not perforate. The plates were made of steel, or a combination of steel and iron.

The CHAIRMAN. Do you think the change of the 10-inch guns we have, by rifling them, would be such an advantage to the government as to justify the money expended?

General BENÉT. I think so, unquestionably. We want a great many guns, and just now we have nothing practically. We have got to work towards steel. That is a question of experiment, partly because we have not got proper facilities in this country. Nevertheless we ought to make a beginning with steel now, and in time (for it will take considerable time) we will be able to do something.

The CHAIRMAN. It has been urged that the rifling of these cast-iron guns in a peculiar way would make them excellent guns and very powerful guns.

General BENÉT. The trouble is that they go to pieces.

Senator HAMPTON. You mentioned just now that we had 1,200 10-inch smooth-bore guns. How many of the 8-inch rifled guns has the government now?

General BENÉT. Of these 8-inch rifles we have 113 that we have converted.

Senator HAMPTON. And how many smooth-bores unconverted?

General BENÉT. We have about 1,100 left of the 10-inch smooth-bores.

Senator HAMPTON. But I understood you to say that you thought the 10-inch was too large to be converted?

General BENÉT. Oh, no; that was the 15-inch. We have about 300 of the 15-inch. We do not think they ought to be converted, because the bore, to begin with, is too short for a rifle of that weight of metal.

Senator HAMPTON. About what would it cost per gun?

General BENÉT. To convert the 10-inch smooth-bore into an 8-inch rifle it has cost about $2,100 per gun. I think if we convert any more it will cost less—under $2,000 apiece.

The CHAIRMAN. Then it costs about half as much as to make the gun originally?

General BENÉT. If you were to make an 8-inch rifle to do the same work, and make it as an original construction, it would cost a great deal more than this cannon. Now, to give you an idea of the power and endurance of these 8-inch rifles that I have been speaking of, here are some results. We fired one gun, for instance, 817 times with 35 pounds of powder, a mean weight of shot of 181½ pounds. The energy of the shot at the muzzle was sufficient to penetrate over 10 inches of wrought iron. Another gun we fired 648 rounds with 35 pounds of powder, and shot weighing 181½ pounds, the mean velocity being a little less than in the other case, but at the muzzle the shot would penetrate more than 9 inches of iron. We fired another gun 783 rounds; we fired that chambered one I was speaking about, with 55 pounds of powder, 172 rounds.

Senator HAMPTON. What was the penetration of that gun?

General BENÉT. With a charge of 55 pounds of powder the penetration of that gun at the muzzle is calculated to be 12 inches. We have never had one of these guns burst or fail in any particular. It seems to me to be a good gun. If you can, at a thousand yards, penetrate, say, 8 inches of iron, it is doing good work. Here is a record of half a dozen, but I give you the record of three that have endured from 648 to 817 rounds, and the guns are good now. Therefore we are utilizing old material, and are working towards an armament by converting our 10-inch smooth-bores into rifled guns.

The CHAIRMAN. You prefer this plan that you suggest now to taking guns and merely rifling them without putting the tube in?

General BENÉT. Entirely so.

Senator HAMPTON. That is not practicable with a large gun.

General BENÉT. If you were to use cast iron alone I do not think the men would stand behind the gun. While one might do very well, another would not. While, as I say, we should begin at once to work up, experimentally, guns of higher power than anything we have yet made, I think at the same time we ought to utilize in some way the material we have as far as we can. The 15-inch smooth-bore, with 100 pounds of powder and 450-pound shot, should penetrate about 8 or 10 inches; and when it strikes, even if it does not penetrate that distance, it is going to shake things up.

It seems to be the opinion abroad now, from experiments made recently at Spezzia, in Italy, with the 100-ton gun against armor-plates, that heavy projectiles will, by their smashing effects, destroy an iron-clad, even where they are not able to pierce the armor. The plates tested at Spezzia came some from France and some from England. Those from France were all steel, and those from England were mainly

wrought iron but steel faced—what are known as compound plates, a steel face welded to wrought-iron backing. The projectiles from the 100-ton gun could not penetrate those targets, but they broke them up badly, and the targets were about 19 inches thick. The shots knocked the targets to pieces by striking about the same spot two or three times. The idea now is that what they want is to have a shot so large that it will act like a ram, and that, if it cannot penetrate the armor, it will jam in the side of the ship. Probably they will have to make larger guns to do that. That is the result of recent experiments in Italy.

The CHAIRMAN. In reference to the recommendation of the Getty Board, speaking of the Krupp gun and the Armstrong gun, if our country should finally come to making guns of that character, have the experiments been sufficient in other countries without our spending money experimentally?

General BENÉT. No; we must acquire our knowledge of how to build guns by experience, just as they have done abroad. In the first place it will require experience and probably considerable experiment to make the steel itself, but after you have got a suitable metal there still remains this important question to be determined, how to mechanically combine the various parts so that the gun shall be in the best condition to do its work. This in fact is the capital operation in gun construction, and necessarily involves experiment. It is a practical question that is far from being worked out to a wholly satisfactory conclusion, even with the best gun constructors of Europe; and, besides, their methods of procedure in respect to these details of construction are just the points on which they do not care to publish any precise information. To give you some slight idea of what is involved in this question, I submit some translations from foreign authors on the resistance of compound tubes, or, what is the same thing, built up guns; so you see this is not only a matter of great mechanical skill, but also of careful mathematical investigation.

The CHAIRMAN. Is your idea that it is not necessary for us to spend money in experimenting in reference to that material because it has already been sufficiently experimented with by foreign countries?

General BENÉT. The question is whether you can get it here. We want steel, but can we make it?

Senator HAMPTON. What does one of the Krupp 10-inch guns cost?

General BENÉT. I cannot tell you exactly. I know that six years ago we asked Krupp what he would sell a 12-inch gun and carriage for, and he said he wanted $46,000 in gold, delivered at his works. That was a gun that would weigh about 40 tons. They have gone up much higher in weight than that. Krupp makes guns of 70 tons weight now. Here is a list which I submitted to the Getty Board, giving very closely the prices of foreign ordnance.

Cost of European guns.

Nature.	Caliber in inches.	Weight in tons.	Cost per ton.	Remarks.
Whitworth 17.78cm	9.75	8.02	$824	All steel.
Woolwich			584 to 727	Wrought-iron tubed with steel. The larger the gun, the less the cost per ton.
Armstrong			727 to 800	Wrought-iron tubed with steel.
Krupp 35.5cm	13.98	51.18	1,300	All steel.
Krupp 30.5cm	12.00	35.43	1,012	
Krupp 26.0cm	10.23	21.65	941	
Krupp 15.0cm	5.9	4.97	1,076	
Krupp 15.0cm	5.9	3.94	1,176	
Krupp 15.0cm	5.9	3.44	1,074	
French 24cm (L. S.)	9.45	15.91	349	Cast-iron hooped and tubed with steel.
French 24cm (L. S.)	9.45	13.75	*1,028	All steel.
Italian 24cm short	9.45	14.91	305	Cast-iron hooped with steel.
Italian 24cm long	9.45	17.02	307	
Italian 32cm	12.6	37.4	259	
Italian 45cm	17.72	99.0	293	

* The cost of the French 10.63-inch (27cm) steel gun is given by Captain Gadaud, in his "Carnet de Notes et Renseignements, 1881," approximately at $762 per ton, and of the 13.38-inch (34cm) steel gun at $684 per ton.

There is another thing to which I should like to call the attention of the committee. If we go into this gun business, I do not see how we can do it under the present laws; therefore I would suggest that there be added in the fortification bill this proviso:

Provided, That section thirty-seven hundred and nine of the Revised Statutes is hereby amended so that its provisions which require that purchases shall be made from the lowest bidder after advertisement, shall not apply to ordnance, and their carriages, projectiles, gunpowder, and other war explosives, nor to the materials entering into the manufacture thereof, and whatever is requisite in military experiments with them.

That section requires that everything purchased for the government shall be under advertisement, and the contract be awarded to the lowest bidder, unless there is no time to do it, and then purchases can be made in market as an exigency. That is the law under which we work. The Navy, however, have always had a law on the statute book by which they make an exception, so that ordnance, and anything of that kind which is special, that cannot be bought in the market, can be procured without advertising. Last year Congress extended the application of that statute to include all ordnance, ammunition, apparatus for their use, and the materials for producing them. Therefore they buy where they can get the best. In making a gun you do not want the cheapest thing unless it is the best.

Suppose we want a piece of steel, we have to advertise for it, and, perhaps the man who will give it to us cheapest is the man who has had the least experience, and we know it, and when we get the steel it may not be up to the standard. You may say, then, go and get it from somebody else, but that involves delay, and a year's time may be lost. Therefore, I think the law ought to be modified, and I strongly recommend that the proviso I have drawn up be added to the fortification bill. That proviso has reference to ordnance materials which are not usually to be had in the market. Take the case of powder, it is as purely a special thing as a gun. The powders that we use now are no more like the powders we used twenty-five years ago than the inkstand on the table before me is like powder.

For instance, with the 100-ton gun each grain of powder is not quite

as big as that inkstand, but not far from it. Each grain is about 2-inch cube. In the 8-inch guns I have spoken of we do not use the old-fashioned powder, but each grain is made separately in a mold, and is what we call the hexagonal grain. There are different shapes, the idea being to put the powder in such a shape, and always make it of such a density that we can regulate the burning of it, that is, to regulate the rate at which the gases are evolved, and thus obtain a more gradual action on the shot. In that way we are able to keep down the pressures and avoid straining our guns. It is a study of itself to try to get the powder that is most suitable for the gun, and actually for every gun there ought to be a special powder if you want to get the best results possible. So all these things hang together. When you make a gun a great deal depends on what kind of powder you are going to use in it. If you use a certain powder that will give you low strains the life of the gun may be extended; on the contrary, a quick powder that will run up the pressures above what the gun is able to resist will cause the gun to go to pieces. The gun is only so strong, and you cannot make it stronger.

Every now and then we hear of a steel gun in Europe breaking, notwithstanding all their experiments, due either to faulty construction or to overstraining the piece, and you must expect the same in this country. True, we have so little of it that when one of our guns does burst people think the Ordnance Department has overstepped the bounds and is going to pieces as well as the gun, but we find the same thing occurring everywhere else. In England they have what they call a cemetery of old guns.

As regards the strength of the metals to be used in gun construction, a rough rule to go on is about this, wrought iron is twice as strong as cast iron, and steel is about three times as strong as cast iron.

In my annual report of this year, and I think I sent several copies to the committee early in the session, I stated in a very few words my views in regard to this matter of procuring an armament for coast defense, that is, my ideas and recommendations in regard to new constructions, and if you permit me I will read from it.

The "Act making appropriations for fortifications and other works of defense, and for the armament thereof, for the fiscal year ending June 30, 1882, and for other purposes," approved March 3, 1881, provides:

"And the President is authorized to select a board, to consist of one engineer officer, two ordnance officers, and two officers of artillery, whose duty it shall be to make examinations of all inventions of heavy ordnance and improvements of heavy ordnance and projectiles that may be presented to them, including guns now being constructed or converted under direction of the Ordnance Bureau; and said board shall make detailed report to the Secretary of War, for transmission to Congress, of such examination, with recommendation as to what inventions are worthy of actual test, and the estimated cost of such test; and the sum of twenty-five thousand dollars, or so much thereof as may be necessary, is hereby appropriated for such purpose."

Under this act a Board, of which General George W. Getty was president, was convened, and after laborious sessions, extending through ten months, made its report to the Secretary of War May 18, 1882. The Board in its report recommended for trial, and for construction and trial, the following guns, viz:

The Lyman-Haskell accelerating or multicharge gun, of 6 inches caliber, for trial.

Dr. W. E. Woodbridge's plan of a wire-wound cast-iron B. L. gun, wire soldered, of 10 inches caliber, for construction and trial.

Plan submitted by the Chief of Ordnance of a cast-iron B. L. gun hooped with steel, of 12 inches caliber, for construction and trial.

Plan submitted by the Chief of Ordnance of a cast-iron B. L. gun, hooped and tubed with steel, of 12 inches caliber, for construction and trial.

Plan submitted by the Chief of Ordnance of a cast-iron M. L. rifled mortar, hooped with steel, of 12 inches caliber, for construction and trial.

W. P. Hunt's plan of a steel B. L. gun, of 10 inches caliber, for construction and trial.

Dr. W. E. Woodbridge's plan of a brazed steel-wire B. L. gun, of 10 inches caliber, for construction and trial.

Plan submitted by the Chief of Ordnance of a steel-wire B. L. gun of 8 inches caliber, for construction and trial.

Dr. W. E. Woodbridge's plan of a steel B. L. gun, longitudinal bars, wire-wound and soldered, of 10 inches caliber, for construction and trial.

A wire-wrapped B. L. steel rifle, after the plan of Schultz, submitted by Col. S. Crispin, of 9 inches caliber, for construction and trial.

This report was transmitted to the Senate by the Secretary of War May 29, 1882, but no action was taken by Congress at its last session to carry out the recommendations of the Board.

These recommendations are now before Congress for its action, and the recent appointment by the Senate of a select committee "to take into consideration the subject of heavy ordnance and projectiles for the armament of the Navy and the sea-coast defenses," and who are to report "to the Senate at its next session," make it proper for the department to await the action of Congress before entering on the manufacture or conversion of heavy cannon.

With the very pressing need for sea-coast armament constantly before us, it should seem expedient to take every advantage of our own resources to help provide for our wants. It will doubtless be practicable for us to produce rifled guns of *moderate power* even from cast iron, provided the cast iron be suitably strengthened with steel hoops, or, better, with hoops on the exterior and a steel tube on the interior. Such guns, however, are very *heavy* in proportion to their power. The substitution of steel wire for the hoops would seem to be an advantageous modification, and its trial, as recommended by the Board, promises important results. A similar plan is now being tried with experimental cast-iron guns in France. For the manufacture of rifled mortars, cast iron strengthened with steel hoops may be used to advantage. In the mortar very great strength is not needed, as the charges employed are small; but since its fire is comparatively uncertain, it is necessary, in order that it may be effective, that what it lacks in accuracy may be made up by the number of mortars used. With such pieces, therefore, cheapness and facility of production are essential requirements, and the small charge and short bore admit of using a comparatively light mortar.

The material out of which *full-power* guns must be made is unquestionably steel. All the first-class powers of Europe have adopted it. Even those that have spent more millions than we have thousands in the effort to determine on the most reliable metal for gun construction, are abandoning cast and wrought iron, either simple or in combination with other metals, and are now devoting their attention to steel, and to steel alone. The marvelous strides in gun construction made within a year or two in the manufacture of guns of great strength and high power point to the conclusion that encouragement should be given in every way possible to the manufacture of steel in large masses suitable for this purpose. At present tentative efforts have developed but little to encourage the hope that steel guns for coast defense can be produced in this country. The use of wire-wound guns, if they prove as successful as recent experiments here and abroad make us hope, will greatly simplify the problem, by limiting the number and size of the steel masses needed, while the wire itself can now be procured from our own manufacturers. Under the most favorable circumstances, however, the country is in no condition at this time to undertake such constructions wholly out of home products, and the subject is of sufficient importance to arrest the attention and receive the careful consideration of Congress. This subject can only be successfully met either by establishing a national foundry or by assisting and encouraging private foundries to procure the necessary plant and experience.

Among the guns recommended by the Getty Board is a 10-inch cast-iron rifle wrapped with wire. We put wire on the outside instead of steel hoops. An 8-inch steel gun would probably do as much work as the 10-inch gun of cast-iron, because cast-iron cannot be pushed as hard as steel. A cast-iron gun hooped with steel was also recommended, but, to quote from my report—

The substitution of steel wire for the hoops would seem to be an advantageous modification, and its trial, as recommended by the Board,

I refer to the Getty board,

promises important results. A similar plan is now being tried with experimental cast-iron guns in France.

Now, in regard to rifled mortars. I have a drawing here of one, also recommended by the Getty Board. The engineers want mortars for vertical fire so as to throw a shell on the deck of a man-of-war, because they cannot afford to put more than a few inches of iron on the deck.

They usually put the bulk of their armor on the sides of vessels. Therefore we ought to have mortars. We can make these mortars; the French have been very successful in the way of cast-iron muzzle-loaders of a type similar to this.

The CHAIRMAN. What is the size of the mortars you propose?

General BENÉT. Twelve-inch caliber.

The CHAIRMAN. How many?

General BENÉT. We want several hundred. The engineers do not say how many, but I think they would want several hundred.

The CHAIRMAN. About what would they cost?

General BENÉT. The Getty Board, on page 13 of their report, say it will cost about $7,000. Of course that is only an estimate; it might go a little above it.

Among the other papers which I have here is a table showing the depth of water at the entrance of particular harbors of the United States at high and low tide, and the number of war vessels having more than 10 inches of armor that can enter each.

Depth of water at the entrance of principal harbors of the United States at high and low tide, and number of war vessels having more than 10 inches of armor that can enter each.

[Total number of such vessels, 50.]

Harbor.	Depth of water at high tide.*	Number of vessels having more than 10 inches of armor that can enter.	Depth of water at low tide.*	Number of vessels having more than 10 inches of armor that can enter.
	Feet.			
Portland	45	All	36	All.
Portsmouth	42	All	36	All.
Boston	34	All	24	10.
Newport	17	None	13	None.
New Haven	20	4	14	None.
New York	28	48	23	10.
Philadelphia	37	All	31	All.
Baltimore	23	10	20	4.
Washington	29	48	26	29.
Norfolk	33	All	30	All.
Wilmington	16	None.	9	None.
Charleston	20	4	14	None.
Savannah	17	None	10	None.
Pensacola	22	10	22	10.
Mobile	22	10	21	4.
New Orleans, &c. (Mississippi River)	26	29	26	29.
Galveston	14	None	11	None.
San Diego	25	21	21	4.
San Francisco	35	All	31	All.

* From the coast and harbor charts of the United States Coast and Geodetic Survey.

I have already given a list of the war vessels of the world and the thickness of the armor in inches, the draught of water, and the armament. Of course, where the thickness is less than 10 inches of armor, we do not think the vessels are very formidable. It may surprise you, but it is a fact, that deducting monitors and coast-defense vessels (that is, vessels which cannot cross the ocean), the number of vessels in all the navies of the world that carry more than 10 inches of armor is exactly 50. They are all named in the list I have presented. Of those that carry less than 10 inches of thickness there are only 177, and of those that do not carry any armor at all, 341.

In regard to what our 8-inch converted guns did, I thought I would

bring the photographs here and you can see how they penetrated and what holes they made. Here are photographs of some of their work. (Exhibiting.)

The CHAIRMAN. Will you put these in testimony?

General BENÉT. Yes, sir; here are some blue prints in regard to these same experiments. I brought them because there has been a good deal said against these converted guns. These are the same experiments, and these drawings show exactly what the penetrations are.

Here are drawings of the guns that I would recommend for construction. (Exhibiting drawings.)

The first, you perceive, has the outline of the gun from which it is converted—that is, the old smooth-bore gun. We bore a hole right through and make the bore a little larger, and then put in a wrought-iron tube. We insert it through the breech, and we shoulder it in so that it cannot be pulled out by the drag of the shot. We put on the tube what we call a jacket, which is also of wrought iron, and that is screwed into the cast iron. That is the gun which withstood all the firing, and has done the work of which I have told you, and we have not had any bursting of the gun. If you tried to apply the system to higher calibers I think you would have trouble, arising principally from the coiled wrought-iron tube. In making those tubes, we take a long bar of wrought iron, thirty or forty feet long, and heat and coil it so as to make it in appearance like a spiral-coiled spring. That coil then has to be heated, the folds closed and welded. The difficulty is to make these coil welds perfectly sound, as sometimes they yield. After our trials, we came to the conclusion that this system would not answer for guns of very large caliber. I think the English have come to pretty much the same conclusion, because all their guns of that kind are small ones. I think they have 2,000 of them, and most of them are of even smaller caliber than our 8-inch gun, what they call a 65-pounder.

The other drawings are of the guns I would recommend to be made if Congress seriously intends making such guns as are necessary to properly arm our sea-coast forts. This is the 10-inch cast iron gun, wire wound. The wire is wrapped around the cast iron. In making one we would run the wire beyond the trunnions, make it a breech-loader, and perhaps put in a tube. That will be carrying out one of the French ideas for utilizing cast iron. My predilection is for steel whenever we can use it, if we are only able to make it. These are the drawings of the steel guns that I think we should make. One is an 8-inch rifle, consisting of a steel tube jacketed and hooped with steel, and the other is of 10-inch caliber, strengthened with longitudinal steel bars and wrapped with steel wire. We may not be able at first to make so large a gun—we may have to begin with a gun of 8-inch caliber. This last plate is the rifled mortar recommended by the Getty Board, and indeed all these guns are recommended substantially by the Getty Board.

The CHAIRMAN. The mortar is made of cast iron, I understand?

General BENÉT. Yes, sir; with steel bands outside. It is a very simple construction.

Senator HAMPTON. Do the mortars throw conical shot?

General BENÉT. Yes, sir. To give the committee some idea of what is being done in the world in the way of heavy ordnance and high-power guns, I will submit these tables, showing the dimensions, weights, charges, velocities, energies, penetrations, &c., of recent European ordnance.

Krupp gives the following table of penetrations for the 30.5-centimeter (12″.0) gun, 35 calibers long; and which contains besides some data respecting the plating of the most formidable iron-clads.

Name of ship.	Nature of armor at thickest point.	The cored shot of Krupp's 12″.0 (35 calibers long) gun penetrates the armor normally.	
		With a *vis viva* of foot-tons per square inch of cross-section.	At a range of yards.
England:			
Inflexible	12″.0 of wrought iron, 10″.8 of teak, 12″.0 of wrought iron, 6″.1 of teak, and an iron skin of 2″.0.	135.34	2,406
Majestic, Colossus, Ajax, Agamemnon	18″.0 of compound armor in two layers and an iron skin of from 1″.2 to 1″.5.	114.57	Over 2,734
France:			
Admiral Baudin, Formidable, Admiral Duperré	21″.7 of steel and an iron skin of 1″.6	172.89	219
Hoche, Magenta, Marceau, Neptune	17″.7 of steel (probably) and an iron skin of 1″.6.	133.31	2,515
Caiman, Indomptable, Requin, Terrible	19″.7 of steel	152.06	1,318
Italy:			
Dandalo, Duilio	21″.7 of steel and a wood backing of 19″.7	172.89	219
Italia, Lepanto	29″.5 of steel and a wood backing of 19″.7	218.72	Not penetrated.

In the Getty Board report they make a remark in regard to the converted guns I have been talking of, and I want to state the case exactly as it stands. On page 8 of that report, speaking of the subject of converted guns, it says:

Although the greater part of the conversions using wrought iron as a lining tube, as detailed in the yearly reports of the Chief of Ordnance, have given in small guns apparently good and encouraging results, it is on the whole, considering the history of all the guns so converted and constructed, including the 11-inch and 12.25-inch, a questionable success.

But in so expressing itself the Board desires it to be distinctly understood that it does not overlook the fact that in the small guns referred to, the 8-inch guns, comparatively ineffective smooth-bores, have been converted into effective rifles.

I.—TABLE SHOWING THE

NATURE OF GUN.	Caliber.	Weight.	Total length.	Leng
	Inches.	*Tons.*	*Feet.*	*Fee*
ENGLISH.				
Woolwich.				
M. L. cannon of coiled wrought-iron, lined with tube of cast-steel. Frazier's system.	16.	80.	26. 9	24.
	12. 5	38.	18. 75	16.
B. L. cannon of coiled wrought-iron, lined with tube of cast-steel. Proposed model.	12.	42.	27. 75	26.
Elswick.				
M. L. cannon of coiled wrought-iron, lined with tube of cast-steel. Armstrong's system.	17. 72	100.	32. 9	30.
M. L. cannon of coiled wrought-iron, lined with tube of cast-steel. Armstrong's system.	8.	11. 45	18. 21	17.
M. L. cannon of coiled wrought iron, lined with tube of cast-steel. Armstrong's system.	6.	3. 9	12.	11.
GERMAN.	15. 75	71.	32. 8	28.
	13. 976	51.	29. 13	25.

it to obtain the same penetration in compound plates, from 10 to 20 per cent. more energy is

CEMENT OF 1880.

NS, CHARGES, ETC., OF T

	(Calculated.)* PENETRATION IN IRON.			POWDER CHARGE.		
	At muzzle.	At 1,000 yards.		Ratio of weight or volume to that of charge.	Weight.	Nature of powder.
	Inches.	*Inches.*			*Lbs.*	
B. L. cannon of coil steel. Frazier's	28.62	22.13	T	.785	286	Prismatic.
	32.17	28.08		.822	300	
	33.90	29.19		.854	311¼	
	20.10	16.84				
	24.14	19.97				
	36.33	28.21	T			
B. L. cannon of coi cast steel. Arms				.....	187.7	German prismatic
				.....	179.4†	1 perforation
	32.11	25.88		.684	325	Prismatic
				.736	350	
				.789	375	
	19.75	13.22				
B. L. cannon, cast s Armstrong's syst	21.85	14.35		.....	500	Prismatic
	23.39	15.15		.945	300 (67)†	
	13.92	7.86		.914	290 (70)†	
	14.47	8.07				
	33.80	29.06		.....	462	Prismatic.
	37.26	31.81				Prismatic
B. L. cannon, steel-t	29.73	24.97		.....	323	Density, 1.82
	25.81	21.09		.853	253	Prismatic
				.....	95.9	Prismatic
B. L. cannon, steel-h						
B. L. cannon, cast ir U. S. proposed B. L.				.770	485	Progressive
				.....	255	
				.....	617	
B. L. cannon, steel-ho				.80	546	
				.95	462	
				.95	337	
B. L. cannon, steel, w				.....	440	
B. L. cannon, cast-iro				.....	176	

10 to 20 t

l projectile is 22:

nose given in table

And then they go on:

Deeming it simply unwise to continue the use of wrought-iron tubes, particularly for breech-loading conversions and all calibers above 8 inches, until it shall have been shown that other conversions and constructions are not what, from the most advanced views, we have a right to expect.

The 12.25-inch that they say is a questionable success, I will remark, was an original construction; it is a cast-iron gun of 12¼ inches caliber, with a wrought-iron tube in it, made exactly as you see on that drawing. In view of the trials made since the Getty Board report was made, I do not believe it would now be called a questionable success. We have been firing it lately and have run it up to over 50 rounds and have increased the charge of powder to 200 pounds with a shot weighing 700 pounds, and the gun is good now and does not show any mark of yielding, so that it may prove to be a complete success yet if we continue firing it.

Senator HAMPTON. What is the penetration of that large gun?

General BENÉT. We never tried it; but I take it for granted, from experiments in Europe and working from the formulas, that it ought to penetrate from 17 to 18 inches of wrought iron. That is about a caliber and a half.

The CHAIRMAN. How many 12-inch guns have we?

General BENÉT. We have only that one.

Senator HAMPTON. A smooth-bore?

General BENÉT. We have no smooth-bore 12-inch.

The CHAIRMAN. How many 15-inch guns?

General BENÉT. Over 300.

Senator HAMPTON. Had you not some smooth-bore 12-inch guns during the war?

General BENÉT. No, sir; we had 8 and 10 and 15-inch. The Navy has 9 and 11, and then above that 15.

Senator ROLLINS. You say that we have 300 15-inch guns?

General BENÉT. Yes, sir, there must be 308 or 310; I do not know the exact number, but over 300.

Senator ROLLINS. Where are they?

General BENÉT. They are scattered about at the forts all over the country, and most of them are mounted. And here I wish to call the attention of the committee to another consideration. A 10-inch smooth-bore gun can be put on a carriage and held without much difficulty; but when it is converted into an 8-inch rifle the recoil is much greater, and something additional must be provided to absorb the recoil. That costs money. For an 8-inch carriage the additions to the old 10-inch carriage necessary to check the recoil will cost from $500 to $600 a carriage. For the 15-inch smooth-bore gun, where we originally used only 50 pounds of powder, we now use 120 pounds of powder and a shot weighing 450 pounds; it will cost from $1,200 to $1,500 a carriage to provide means to check the recoil and facilitate maneuver, otherwise it will turn a back summersault. So the whole subject is one that requires the expenditure of a great deal of money.

I would recommend that the money be appropriated to properly mount all the 15-inch guns in our forts. They are good guns for secondary purposes. Let them be provided with a recoil check, so that they can be used. But we *must* see if we cannot make steel guns in this country; we must do something in that direction. We *ought* to do it immediately. It is the only way in which we can eventually work up to the monster 100-ton guns that are indispensably necessary to the defense of all our important harbors, and to cope with the ships and guns of modern European navies, for in steel we have no practical

experience, and the sooner we commence the better. This building of guns has advanced beyond the point where it merely required a mass of metal of any kind simply cast into form, and has grown to a science, as you will see when you look over the papers I have submitted. The energy of Krupp's 12-inch steel gun, which is a high-power gun, is, you will see from the tables, about 20,000 foot-tons, while that of the Armstrong 100-ton gun is about 40,000 foot-tons, and that is the energy required to smash in the plates and backing after the fashion of the late Spezzia trials.

The CHAIRMAN. If we were to make some cast-iron guns, what size would you recommend?

General BENÉT. I would make a 10-inch gun, nothing below that; put a steel tube in it, wrap it outside with wire, and make it a breech-loader, and test it. I think it would make a very efficient gun.

Senator HAMPTON. What would be the caliber of the rifle when you put the tube in?

General BENÉT. The object of the tube in this case is to assist in holding in the breech-block, to give the gun longitudinal strength, as it is termed. It is wanted at the breech, and only extends as far as the trunnion. The bore would be 10 inches.

The CHAIRMAN. How many would you suggest of that kind?

General BENÉT. We should want to make one first, and try it before making the guns in quantity.

Senator ROLLINS. Using a steel tube?

General BENÉT. Yes, sir. Some would try it without a steel tube. I do not know but that if I went into it I might try one with a steel tube, and one without it, merely using the cast-iron for the bore, but in both cases strengthening it on the outside with wire. I am always willing to shoulder all the responsibility; and we must expect failures, as every country on the face of the earth has had them. We have had some and we must expect more. Gunpowder is a treacherous thing to manage.

The CHAIRMAN. I should like to have you examine all the different propositions submitted to the committee and suggest what you think would be liberal and fair. My notion is that the government, if it does not take too much money, whenever a good thing is submitted, ought to test it. I should like you to examine these propositions and give us your views about them.

General BENÉT. I shall be very glad to do it. In regard to inventions, I get, I suppose, 365 inventions a year of all kinds, and parties say, "We think the government ought to try this thing on its merits." I say to them, "If you can get Congress to give me a million dollars a year, I think I could try almost every thing. I cannot do it with the present appropriations." If the invention is a success, the parties interested are going to charge a royalty. Therefore, as they are interested, they ought not to expect the government to bear all the expense. If a man brings a shot to me I refer it to the Ordnance Board (who are in session all the time and have more than they can attend to now), and they examine it, and if they say it is a good thing and ought to be tried, I ask the inventor to let me have a small number for trial made at his expense, and the government will supply the gun and powder to try it. We divide the expense in that way. Sometimes they do it, and sometimes they do not. Sometimes, if it is a thing that we think very highly of, we stretch a point and make the experiment fully; but there is not more than one case out of a hundred where we would take the risk of spending any money. That is the usual rule of practice. Some of our best inventors never would have succeeded if they had not had sufficient faith in their inventions to risk a trial.

GENERAL S. V. BENÉT'S STATEMENT CONTINUED.

General S. V. BENÉT, U. S. A., recalled.

The CHAIRMAN. You did not get through the other day.

General BENÉT. I got through upon the general subject which I was discussing; but you intended that I should look over the papers which have been submitted by other parties and you wanted to ask me some questions. I have not seen the papers, but perhaps I can answer the questions. All these subjects have been before the country more or less heretofore.

The CHAIRMAN. In your opinion what number of guns, no matter what patterns may be selected, should be attempted to be wrought at this time, either changed or made; and what different sizes do you think we ought to have?

General BENÉT. Do you mean at this epoch, or this year?

The CHAIRMAN. I mean upon the general subject.

General BENÉT. I would say that to begin with the material we have on hand, we ought to continue the conversion of the 10-inch guns I spoke of the other day until we convert at least 300 of them, making the 10-inch cast-iron smooth-bore guns into 8-inch rifles. I would go on with the work and adapt the carriages to the converted guns; we have carriages for them, but they require to be altered; some money has to be expended on the carriages in order to make them serviceable. I would at the same time go on to suitably modify the carriages for the 15-inch smooth-bore guns, to admit of the use of an increased powder charge; we have 300 of these guns and nearly enough carriages to mount them, but only about one-half of the carriages provided with recoil checks, and I think we ought to commence work on placing all these carriages in a serviceable condition and mount these guns on them.

The CHAIRMAN. We have already the 300?

General BENÉT. We have 300 15-inch guns. It is merely a question of carriages and mounting as to them. In regard to the other recommendations that I made, of necessity they must be of an experimental nature.

You asked a question the other day that I answered, but probably not as fully as I might have done; and that was as to the use of making experiments in this country when similar experiments had already been made abroad, which was a very pertinent question.

The reason is this: That while we know exactly what we wish to do, the very end sought by experiment is the knowledge of how to do it, and experiments abroad do not furnish us with that knowledge; we must begin it for ourselves. We must first learn how to make the proper metal. We want steel for gun construction; we must learn in this country how to make suitable steel for that purpose. It is not every mass of steel that is made that is fit for a gun. In order to practically work out the question here, we must begin with the smaller masses used in the lighter calibers of guns, and when we have succeeded with those, to increase our plant and go up to the heavier masses required for larger guns until we are able to produce guns of 100 tons, or even larger, if necessary. This is working up the material and is one line of experiment. Then another line is this, after we have got the steel we need experience in the mechanical shaping and fitting of the various parts that compose the gun; and in so combining them under that degree of shrinkage or tension as shall place the finished

gun in the best condition to resist the strains that we expect to put upon it; that is, for a given weight and quality of material, we wish to make the gun as strong as possible. That requires a great deal of skill and the necessary knowledge, that can only come through experiment. Therefore when we test a gun we are not only testing the quality of the material that enters into its construction, but we are testing the character of the workmanship and the soundness of our rules for building up or assembling the gun. If the gun proves a success we may conclude that the metal is good and that the system of combination is reliable for the caliber tested, and we should be justified in producing in quantity guns of that type and caliber. In the same way we should proceed with each caliber, making first sure of the ground on which we stand by carefully conducted experiments, before going extensively into manufacture, and before making any step in advance, so if we are going to procure anything more formidable than we have at present for the armament of our coasts, we must begin with experimental guns.

This leads me to refer again to the guns of this character that I would recommend for construction and trial. I should wish to make, say, two mortars of cast iron, one to be strengthened with steel hoops and the other with steel wire. There should be very little difficulty in making those pieces. I would not recommend the manufacture of more than two, because, as I have said, this is an experiment. We want to see what we can do; we want to see whether we can get the material for the bands of the right quality, and whether we know exactly under what tension to put them on the cast-iron body of the mortar; we wish to ascertain if we have employed the proper shrinkage to get the best results.

In the same way as regards wrapping wire. We have done a little of that here in one gun on the Woodbridge system, but we desire to make further trials, and we must test it experimentally before we go into it on a large scale. There is no difficulty in procuring the cast-iron parts. We have as much experience in that manufacture in this country as they have in any part of the world. In the cast-iron guns that I want to try wrapped with wire or with bands around them we shall have no trouble in making the cast-iron body; we know all about that. I would recommend two such cast-iron guns, one with hoops and one wrapped with wire, to be new constructions and breech-loaders and of such length as will give as high a degree of power as can be obtained without adding too much to the weight of the gun.

Then I most urgently recommend the manufacture of two all steel guns, say of 8-inch caliber, because that is the largest gun that can probably be made in this country at this time. I should want to make one of those 8-inch guns of the steel band construction and the other a wire-wrapped construction, making them both breech-loaders and guns of full power. That is my recommendation, and I do not see any other practical way of conducting the matter in order to arrive at any sensible conclusion.

If the committee should decide upon carrying out the scheme which I have presented, I think that probably the sum of $350,000 or $400,000 would suffice for this year, because if we got more money we could not spend it judiciously, and I would not spend it unless I knew exactly what I was about. But the question of steel is one that we ought to go into; there is no doubt about that; and unless there is a disposition on the part of Congress to go into the matter I do not see what encouragement can be given to manufacturers here.

The CHAIRMAN. What do you think about testing some of the inven-

tions of guns which have been presented to the Ordnance Department and to the Getty Board?

General BENÉT. I think whatever might be done in that direction ought not to interfere with the scheme I have presented in regard to new construction.

The CHAIRMAN. I am not speaking of it in connection with that; but what do you think of the government giving facilities for testing such guns as might seem valuable?

General BENÉT. I think it all very well where the invention is one that promises favorable results. In any system that is presented the only novelty that we are likely to find at present would be in regard to the breech arrangement or closing of the breech. We take it for granted that the guns when made of high power must necessarily be made of steel until we find something better, and the system of built-up construction seems to be pretty well defined, therefore the question would reduce to the simple testing of a breech mechanism. It comes to that. Now we know that in the world there are two breech systems which have been tried and have been accepted, they are the Krupp breech blocks, and what we call the slotted screw or the French block, both of which are indebted for much of their merit to American invention.

The Krupp system is used in the Krupp guns. Krupp has made more guns on that system probably than have been made on any other system. The Russians also have made some on that system, though they are now experimenting with the slotted screw, but the rest of the European nations evidently prefered the slotted screw. I am in favor of the slotted screw myself, and I think any guns that are made by the government ought to be made with that breech arrangement for this reason, that with that system we use smaller masses of steel than we do with the Krupp. Krupp can make large masses of steel because he has the experience and possesses an immense plant; but where we are making a beginning, the smaller the masses of steel we have to work the better we can make them. So far as mere working goes, the two systems seem to be about equally balanced, as far as we are able to judge.

Now if you come to any novel system of breech construction, necessarily it must be something very novel, and that promises most admirable results, before there would seem to be any warrant why money should be expended in testing it. I do not know that any other breech system that I have seen or heard of promises any better results than the two systems which are being used all over the world. You may find a breech system that probably is equally strong, but then it may be very cumbersome; it may be very complicated. Therefore there would be an objection to that. Then there are other systems that seem to be very simple but actually do not promise good results. So that in regard to breech-loading arrangements I do not know of anything that I would recommend the expenditure of money to make a large gun in order to test the system, when we have two systems that are adopted by the world and have been tested to a remarkable degree with guns of all sizes. The Krupp system has been tested from a field gun up to guns of 72 tons weight. Therefore that system has been successful through the whole range of guns. Take the slotted screw that has been tested from field guns up to 100-ton guns. The gun that was fired at Spezzia the other day, fired against steel plates, &c., was a 100-ton breech-loading gun on the slotted-screw system. Therefore those two systems have been tested satisfactorily all the way up to the very

heaviest gun, and thus we know that if we employ them in making guns we cannot go wrong.

It must be something remarkably good to induce us to change to something else; not that others may not have merit, but that these are so far superior to anything else that has as yet been presented, at least so far as I am able to judge.

It is very much like a breech-loading rifle, for instance, that you fire from the shoulder. I suppose there may be fifty or one hundred different kinds, any one of which fifty years ago would have been considered a wonder, and now, out of these there are only two or three or half a dozen that people will use, not that they all have not merit, but that some are much more meritorious than others.

The CHAIRMAN. How many did the Getty Board recommend a trial of?

General BENÉT. The Getty Board recommended ten different guns. One was the Lyman-Haskell multicharge gun, in reference to which a gentleman presented a paper the other day while I was here, and the remaining nine are embodied substantially in the experimental guns that I have recommended. They are all from general types recommended by the Getty Board. So there is nothing new in them. Of course, as to the Lyman-Haskell gun, they merely recommended that it should be tested because they knew the gun was under fabrication.

The CHAIRMAN. Which one of the systems is that?

General BENÉT. That is the one with little pockets.

The CHAIRMAN. I understand; but under what plan is the breech-loading arrangement?

General BENÉT. The plate that accompanies the report of the Getty Board is on the Krupp system, but the gentleman in his speech the other day said that they had changed it for the slotted-screw system, although the gun is not finished yet and probably may not be finished for some time.

The CHAIRMAN. Suppose that the committee should adopt the theory that you could expend $300,000 or $400,000 in converting and in making such guns as you would like to have made for the purpose of tests; then what other recommendation would you make in reference to an appropriation for testing such guns as you might deem promised success in case such guns were presented?

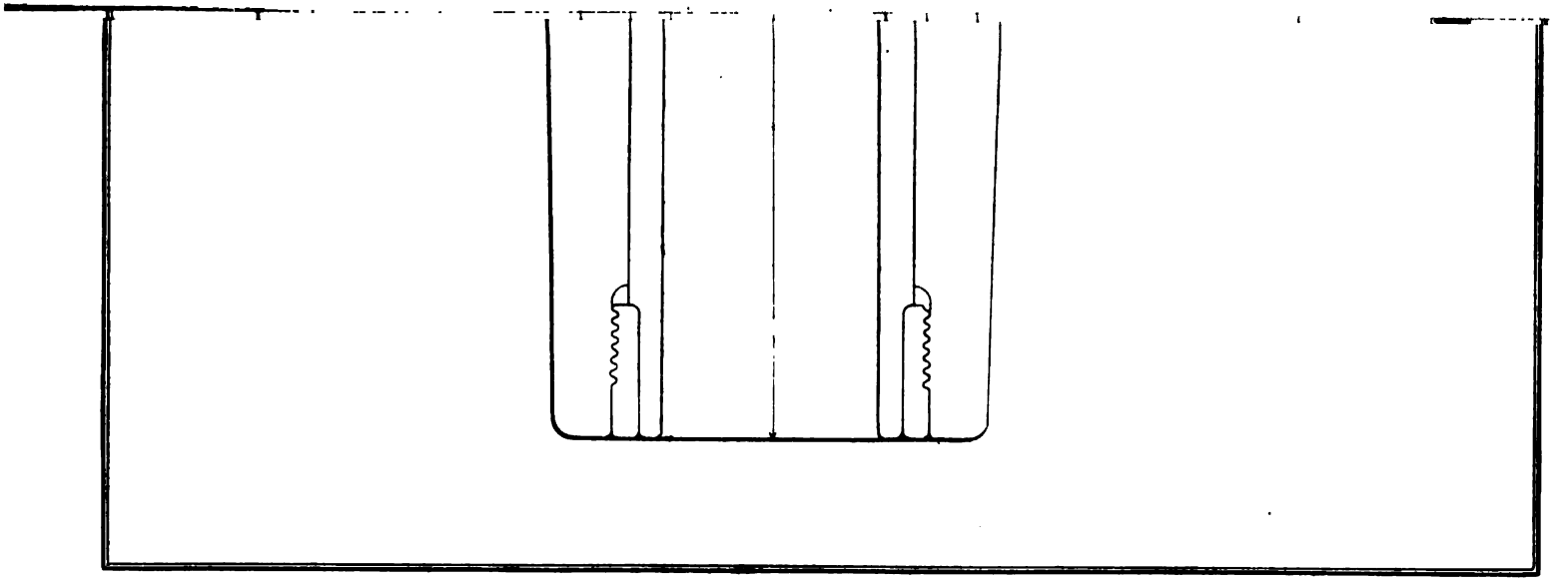
General BENÉT. It is very difficult to answer that question because it depends upon the size of the gun. You may have a gun of a certain size that would cost $100 every time you fired it, and, again, there might be others that it would not cost more than $50 a round. A small gun should be fired between 500 and 1,000 rounds in order to test the system thoroughly; with very large calibers from 200 to 300 rounds would suffice.

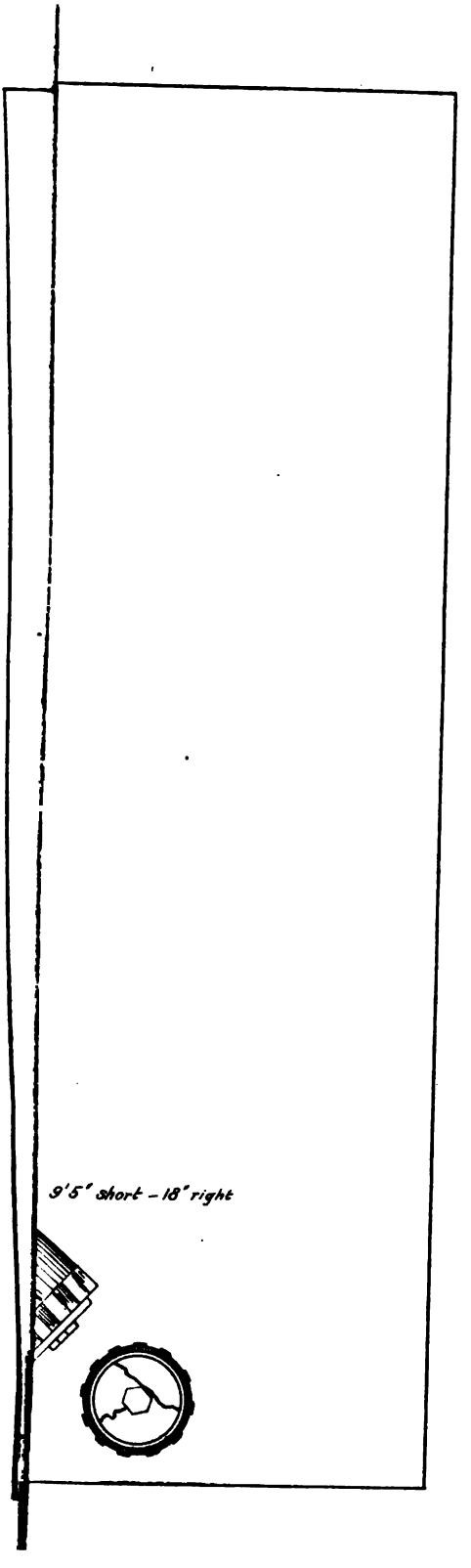
The CHAIRMAN. For the purpose of testing a gun, I suppose you would not make the largest gun first?

General BENÉT. I should not. In gun construction we always believe in beginning at the bottom with the smaller calibers and then working up, because as you increase the size of the masses employed in construction difficulties of fabrication are very much increased, and, hence, while an inferior metal may answer for a small gun, only the very best will answer with a large gun.

The CHAIRMAN. The 8-inch gun, for instance?

General BENÉT. Take the 8-inch gun. If that is a success then you can go up from that to a 10-inch gun; but you cannot say that a 12-inch is going to succeed because your 8-inch has succeeded; you can only

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No. 9.

WOUND. 25

DGE. ———

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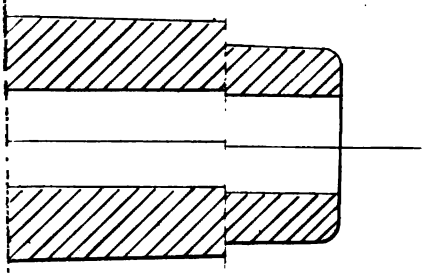
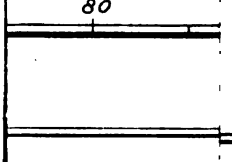
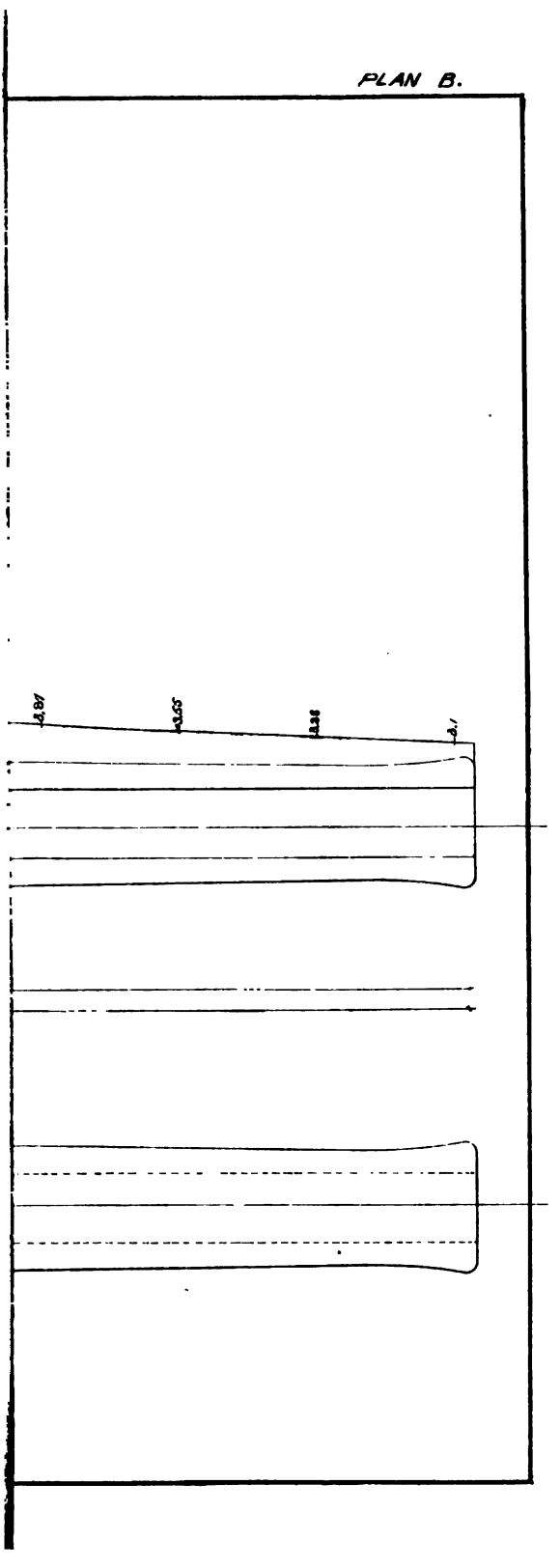
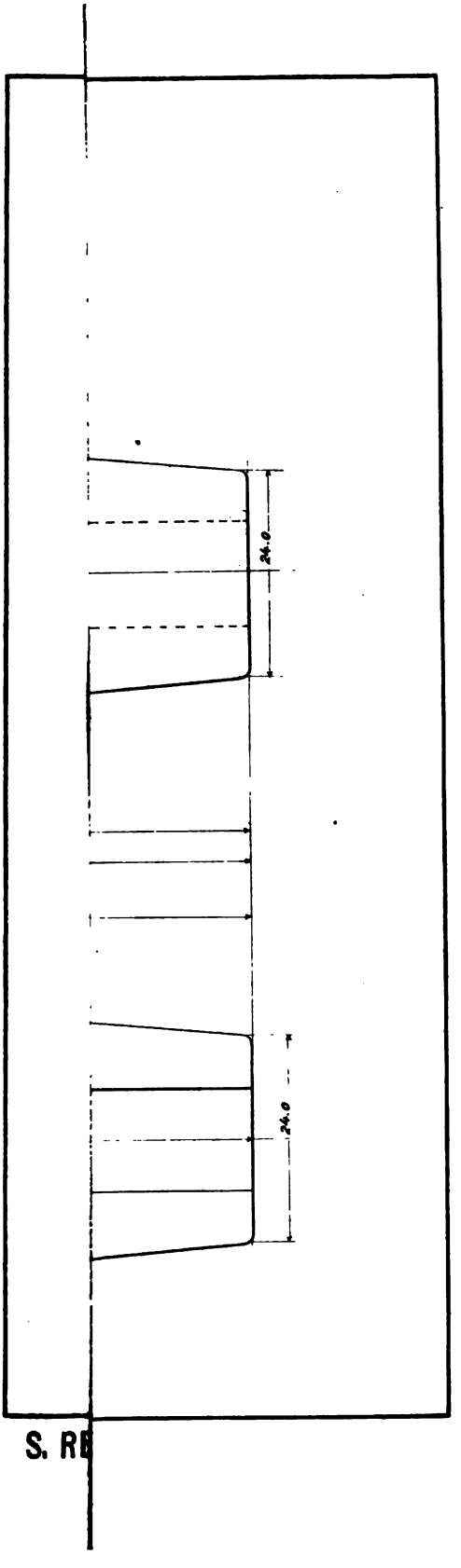
400 „
652 feet per second.
.16 tons per sq. inch.
570 tons.
15.36 inches.
13.75





PLAN B.

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say a 12-inch gun is going to succeed after you have tried it and proved it to be a success.

In regard to testing guns, we find in the Getty Board report that as to the guns they have recommended they have stated exactly how much each round would cost to test it. They have put down what they estimated would be the cost of the gun. They have stated exactly how much powder, and projectile, and labor, and so forth, would cost for every time it was fired.

I should like to refer again to the subject of amending the section of the Revised Statutes as I suggested, so as to enable us to get steel and other materials without advertising, and having to accept the lowest bid.

In the naval appropriation bill of last year, referring to section 3721 of the Revised Statutes, which allowed the Navy to procure ordnance, gunpowder, &c., without advertising and awarding contracts to the lowest bidder, they had this provision inserted:

The words "ordnance" and "gunpowder" in section thirty-seven hundred and twenty-one of the Revised Statutes shall be construed to mean offensive and defensive arms, ammunition, and explosives, the apparatus for their military use, and the materials for producing the whole, and also transportation, necessary information concerning them, and whatever is requisite in military experiments with them.

You see how broad the provision was made. That has exempted the Navy as regards these subjects from the operation of the law that requires advertising and buying from the lowest bidder. I would submit an amendment to cover this very ground, that is to put us upon the same basis that the Navy is placed by law, and I would make the amendment that I suggest to the fortification bill:

That section 3709 of the Revised Statutes is hereby amended so that its provisions which require that purchases shall be made from the lowest bidder after advertisement, shall not apply to "ordnance" and "gunpowder," as these words are construed to mean in the act making appropriations for the naval service for the fiscal year ending June 30, 1883, and for other purposes.

It shows upon its face that it is merely putting the Army upon the same basis that the Navy has been placed by the law, and, therefore, I do not think there will be any objection to it.

The CHAIRMAN. Have you said all you desire to say?

General BENÉT. That is all. If there is any further information or assistance I can give the committee, I shall do it with great pleasure at any time.

The CHAIRMAN. Please take the statements and testimony submitted to us and make such suggestions as you wish in connection with them. Make them in writing, and submit them to us.

General BENÉT. I will do so.

Mr. DAVIS. Mr. Chairman, may I be permitted to ask General Benét a question?

The CHAIRMAN. Certainly.

Mr. DAVIS. General Benét, you stated that your idea was to get to the use of steel as fast as possible, and of course everybody is much interested in that question. In the present condition of affairs, would you consider it inexpedient absolutely for the committee to recommend an amount of money for the building of some intermediate guns that can be made with the present facilities?

General BENÉT. In the recommendations that I have already made, that object is in view. I would test some guns made of cast iron strengthened either with steel bands or with steel wire. I have also recommended the trial of cast-iron mortars, hooped with steel, or wire wrapped. I

should say that if I had the money, I would probably start perhaps half a dozen of such cast-iron constructions, that is, in which cast iron came in, believing that we could then determine upon something that would make a very good gun, although not what is known as a high-power gun, but a gun simply of moderate power.

The CHAIRMAN. Half a dozen of what character of gun?

General BENÉT. Of those where cast iron enters into the construction; that is, a cast-iron gun wrapped with wire or banded with hoops, and either tubed or not. In that way, probably, we could very deliberately work up, during the year, half a dozen of these guns that contain cast iron.

The CHAIRMAN. Of what size?

General BENÉT. In these experiments I would not go higher than a 10-inch gun. While I think we ought to go into steel as soon as we can commence, we can, at the same time, provide ourselves with guns of intermediate power, in the way I have stated, which, in an emergency, would tide us over till we are able to produce steel guns of large caliber, and in sufficient numbers for the proper defense of the coast.

STATEMENT OF WILLIAM P. HUNT.

The CHAIRMAN. Please make such statement to the committee as you desire.

Mr. HUNT. I want to say a few words on the other side of the cast-iron question to that presented by General Benét. We have an extensive plant where we make cast-iron guns. For a great many years we have made 9-inch and 11-inch which are well known to be very powerful guns, and I wanted to call attention to the evidence that General Benét has given—that there are 113 of these light guns, as he calls them, which have stood heavy endurance as he admits, and that there has never been one of them that has failed, although they have been fired with 55 pounds of powder, and several hundred rounds, and although all of them have been fired with 35 pounds of power, and there are over 100 of them that never have failed, and it is a fact that they are a lighter gun than the steel guns of the same caliber. They are a very light gun, only about eight tons.

In speaking of the strength of materials, General Benét says that cast iron is about half the strength of wrough tiron and about a third the strength of steel. I do not know but what if you take Scotch iron, which is not more than 12,000 pounds to the inch, and make an average of the amount of cast iron used, that would be a very fair and correct estimate; but the fact is that all guns in order to be acceptable to the government have to be over 30,000 pounds to the inch, while it is a well-known fact that wrought iron is not over 6,000 pounds to the inch, so that it is not fair to class gun metal with ordinary cast iron.

I should like to ask General Benét if he knows of an instance of any kind of a failure of a cast-iron gun since the improvement in gunpowder. I should like to ask him in regard to the failures that have been made. For instance there was a 10-inch coiled tube rifle that failed; the tube was blown out of the gun, but the cast-iron gun was not injured. It broke off at the muzzle because the tube came out, but it did not break the cast-iron gun.

My argument is, that with the improvement in gunpowder the strain

on the gun has been very much reduced. Cast iron has not had any trial whatever. I do not know of any trial where cast iron, pure and simple, has been tested. I say it is going too fast to assume that a mortar ought to have steel rings around it, or to assume that cast-iron pure and simple must break, until we have first broken one with improved powder.

Then I make this argument, that there is not any instance, and I should like to call on General Benét to tell me of one instance, where there has been a failure of an American cast-iron gun with modern powder. If there is not, I think it is only simple justice to have a trial of cast iron. It is not an expensive matter; it is a very cheap matter.

I offered to give the constructor of ordnance once the use of a 10-inch cast-iron rifle without cost if he would fire it to see what it would take to break it. He never accepted it. I am ready to-day to contract to furnish a cast-iron gun to the government and guarantee it to endure one hundred rounds with the service charges that are used in Europe in a 10 or 12-inch gun. I will guarantee it to endure 100 rounds. I have no doubt it will endure seven or eight hundred, the same as the others, but 100 rounds for a gun of that kind is as much as will probably be required of it. The Italian gun that the General speaks of is a 100-ton gun, and has been fired over 400 rounds. It is a cast-iron gun. There is no other record in Europe of a 100-ton gun having been fired so many rounds as that.

General BENÉT. It has bands of steel.

Mr. HUNT. It is a cast-iron gun with steel hoops, but there is no record of any other gun having been fired 400 rounds. No one knows, of course, what that gun will endure, because it has not been broken, and still it is good. The fact that the Italian government has decided not to have any more is something that I cannot account for. Of course that has great weight, but why they have decided so I am sure I do not know, but from the record it would seem to me that there was no good reason. As long as they have a gun that has done better than any other gun in the world, I do not know why they should be dissatisfied with it until they have evidence against it of some kind.

The general theory being that steel is stronger than cast iron, it does not follow that a steel gun of a dozen pieces is necessarily stronger than a cast-iron gun of one piece. There may be objections to making a gun of several pieces. If you have a gun made up of pieces you have to have additional strength to hold those pieces together in order to get the use of all the strength.

All I want to say in substance is that cast iron pure and simple has not had a fair trial, and to show my confidence in it I am willing to furnish a gun that will cost $30,000, and assure the government that if it does not stand it will be no cost, provided, if it does stand that I shall have a reasonable contract to warrant me in taking the risk.

Now, as to steel, I have connections with other establishments, so that I can get steel to advantage. If I could import foreign steel I would undertake to furnish a steel gun to the government within twelve months of 10-inch or 8-inch or 6-inch. I am ready to guarantee it to give a velocity of two thousand feet a second, and I am ready to commence the manufacture of those guns without delay. I could probably furnish the first gun within a year, and after that could furnish perhaps one a week.

The CHAIRMAN. Steel guns?

Mr. HUNT. Steel guns; but I should have to import the steel. I am ready also, with sufficient encouragement from the government, to com-

mence the plant for the manufacture of steel here. I do not think any one will undertake such a plant without some government encouragement, in the shape of a guarantee of some kind. I am ready to do that. At the same time, cast-iron guns would be less than one-half the expense of steel, and up to the present time, I say, there is no evidence whatever that they will not do the work. The gun that was fired at Sandy Hook with two hundred pounds of powder was a cast-iron gun; and about the little guns General Benét spoke of, what is the cause of their endurance? The only difference between them and a simple cast-iron gun is that they have a wrought-iron tube. It is a question whether the wrought-iron tube adds strength or detracts. Some officers think it detracts from their strength; that they have stood this endurance in spite of the wrought-iron tube, rather than by the aid of the wrought-iron tube. That is an open question which has not been tried. What I want is to have it tested. If these little 8-inch guns would be as good, if they were made entirely of cast-iron of that particular form, as they are now, it would be much cheaper to make them in that way than it would be to take the others and convert them, because they could be made of that particular weight and purely of cast iron for about the same that it costs now to convert them.

The question is, Why have these little guns endured so much? It is admitted that there never has been a failure. Shells have been exploded in the guns repeatedly, which is a severe trial for any gun, and they have never broken one. That shows uniformity. The general says that while one cast-iron gun does well, there is no assurance that the next one may not break. Here are 100 that never have broken. I say that is evidence of uniformity, and I do not see that it is right to condemn cast iron on a record that is so good. Before the war, when we had quick-burning powder that caused strain on the guns of from 50,000 to 60,000 pounds to the inch, whereas now we only have about 30,000 or 40,000. I say the strains in all the trials that have been made, even in Europe, with the high-power gun, are much less on the gun than we have repeatedly had on the 9 and 11 inch Dahlgren gun; so that I do not think it is right to conclude without a reasonable trial on so important a matter.

As I said before, I am ready to back up my convictions by offering a gun to the government free of cost for trial. If the government says "steel is better than cast iron, and we do not want to take an inferior metal," I am ready to give the government within twelve months a 10-inch, 8-inch, or 6-inch steel gun finished ready for trial, and guarantee it to give a velocity of 2,000 feet a second. If there is any one who can make any better proposition than that, let him make it. If that is not reliable, I am ready to bring indorsers who will make it reliable.

General BENÉT. I should like to make one remark in regard to what Mr. Hunt says. A great deal of what he says is true, but the trouble is here: If we could take a cast-iron gun and be sure to keep the pressure, that is, the strain on the gun, down to a minimum, and uniformly so, the probabilities are that a gun made even of wood perhaps would stand very well. The difficulties, though, that stare us in the face are these: From our experience up to the present time we must expect abnormal strains. In some of these little guns we have had the strain jump up to 70,000 pounds to the square inch. Whether a cast-iron gun would stand that is a question. It could not stand it very long. We have made great improvements in regard to gunpowder, but we have not got to that stage at which we are sure that every time we fire a gun we get the pressure up to a certain point. It is very true that the ques-

tion of cast iron has not been tried since the war and since we have made the improvements whereby we are enabled to keep down pressure. When we did make experiments before the war cast iron was like the guns, did not work at all.

Mr. HUNT. There is the fact that with a cast-iron gun 120 rounds have been fired in one instance you have cited.

General BENÉT. But while one gun may have been fired 120 rounds, another of the same kind might go to pieces at the third or fourth round. That is one of the difficulties in regard to cast iron; it is a treacherous metal. Then, again, with all the improvements we have made in gunpowder, we cannot tell exactly what that gunpowder is going to do, and when you least expect it from some unknown cause, your pressure, instead of being down to 30,000 pounds to the square inch, will jump up to 70,000 or 80,000 pounds to the square inch. When you make your gun you must expect to meet just such abnormal strains. Therefore, what we have got to come to is to get the strongest metal we can.

Mr. HUNT. Here is the record of over 100 having been used for a series of years without any failure.

General BENÉT. That was cast iron with a tube that strengthened it.

Mr. HUNT. Yes; but you know some officers claim that the tube does not strengthen it. What I want is to have that tried. It will cost perhaps $2,000 to make a cast-iron gun of the same exact dimensions as the converted gun, and then if that was fired 800 rounds it would go to show that it was as strong as the other.

General BENÉT. The difficulty in that case is this, if you took a cast-iron gun and made it so that it stood 800 rounds, it would not inspire confidence enough that the next gun you made would stand ten rounds. That is the difficulty.

Mr. HUNT. That brings us right back to the 113 that have been converted without one failure.

General BENÉT. They have not failed so far.

Mr. HUNT. I do not object to converted guns. I am only saying that cast iron, as a material, has been condemned without a trial.

General BENÉT. But we know it has been condemned all over the world. They do not use it anywhere, except in combination with other metals.

Mr. HUNT. However, I am ready to make steel guns if I cannot make them of cast iron, but I must import the steel. If I can have encouragement to make the steel, I am ready to commence with making steel here and make it as quick as anybody.

General BENÉT. That I have recommended, and I think some encouragement ought to be given. We have not got a national foundry, and if we cannot get steel anywhere else, we should encourage our people to make it.

Mr. HUNT. My argument is only to show the other side of the cast iron question.

General BENÉT. I agree to a great deal of what you say.

Mr. HUNT. Here is a wonderful record. You cannot find 100 rifled guns in Europe that have not any one of them failed, whether of steel or any other metal.

The CHAIRMAN. How large a steel gun do you think ought to be made for an experiment, General?

General BENÉT. My idea is on the supposition that we should have to work up things as the Navy has been trying to do, and to get our steel in this country. My idea was to try an 8-inch gun, and go higher. As you increase the caliber you increase the difficulty largely. There-

fore we have got to begin at the beginning and crawl up. We cannot do anything else.

Senator HAMPTON. What is the size of the Krupp gun you spoke of?

General BENÉT. That was a 12-inch. I think the last Krupp gun was 16 or 17 inches caliber—a 72-ton gun.

Senator HAMPTON. Mr. Hunt, what would be your estimate of the cost of a steel gun?

Mr. HUNT. A 10-inch gun would cost $35,000. That is what is recommended by the Getty Board for a steel gun. We proposed an 8-inch gun, and the Getty Board accepted the design, but wished to have it a 10-inch gun instead. For the 8-inch gun the price was $35,000.

Senator HAMPTON. For a 10-inch?

Mr. HUNT. And for a 10-inch.

General BENÉT. I make not the slightest objection to the recommendations of the Getty Board. In what I have stated this morning I have run in that line in general terms.

Mr. HUNT. If a 12-inch rifled gun could be made for $25,000 that would penetrate 15 inches of plate, and was guaranteed to endure, and had fired a sufficient number of rounds to warrant that it would endure, I should like to ask if that would not be an economical and desirable thing for this government?

General BENÉT. I think it would be a very excellent gun. I would not consider it a full-power gun; that is, a steel gun of the same size that would cost more money would do a great deal more work.

Mr. HUNT. Although I would guarantee the gun to stand a charge of from 150 to 200 pounds of powder, I should expect that gun to endure a great deal more powder. I do not think the pressures they receive in any of the high-power guns in Europe are more than cast iron can endure. That is my honest conviction about it. If that is the case, it certainly ought to be tested. If that is the case, it is a great object to find out. I understand perfectly well that steel in the abstract is much stronger than iron; but I heard Commodore Chotard once say that in making up a steel gun a margin of 50 per cent. should be allowed for imperfections of temper and imperfections of mechanism. I think you do not take into account that that is wiped right out in the steel to start with. I believe that it is highly important to this government to make a commencement in the direction of producing steel not only for guns, but for all kinds of heavy forgings, for steel shafting for steamers. We propose to build steel cruisers. Where are we going to get suitable shafts for the cruisers? There are no facilities in this country for making such shafts as are wanted, and they cannot be obtained in any other way than by beginning a plant and having the requisite tools and appliances. Thus it is of vital importance to the government to commence to provide at once, not only for gun, but for other material that will be required in the construction of a Navy. I believe cast iron ought to be tested with the improvements in projectiles and powder. The old guns broke with bad projectiles and very weak powder.

The CHAIRMAN. Is there any new system of rifling that you think of?

Mr. HUNT. No; I do not speak of rifling, but of the improvement in gunpowder and in projectiles.

The CHAIRMAN. Are you speaking of a smooth-bore or a rifled cast-iron gun?

Mr. HUNT. I am speaking of a cast-iron rifle. There is no difficulty in rifling the cast iron as a material, but it would be very necessary to insert a hardened bronze tube, which, I think, would be as good as a steel tube. There is no objection to a steel tube if it is thought desirable, but it would be expensive, and I do not think it necessary.

The CHAIRMAN. What do you think would be the real cost of taking these guns and converting a 10-inch smooth-bore into an 8-inch rifle with a wrought-iron tube?

Mr. HUNT. The cost of this is about $2,000. The original cost of the 10-inch gun was $1,600. The cost of converting it is $2,000. That makes $3,600 for the whole gun when converted. A new gun could be cast of that shape without the tube at as low a price as the conversion, about the same; but, then, there is this question: We know that these converted guns have all stood wonderfully; there is not an exception. It may be, as General Benét thinks it is, owing to the tube. All I say is that there has been no trial to prove that it is owing to the tube. The only trial which has been had, and it may not have been a full trial, went to show that the tube is not an assistance, but there has been no full trial to show it, and it is a thing which it seems to me ought to be tested.

General BENÉT. Originally when we commenced the conversion we could not get wrought-iron tubes in this country. Although the West Point foundry said they would undertake it, they could not do it, and I sent to Sir William Armstrong and got tubes there. Now we make the tubes better here than they can in England. We converted one gun with a wrought-iron tube from England, and one with a steel tube from England, and Mr. Hunt has made reference to that gun. After firing it probably 150 times the steel tube split from the muzzle to the breech. It was held together by the cast iron, and I think the gun was fired two or three hundred times after that before it burst. Of course the cracked steel tube must have helped it some, but the cast iron held the thing together up to that time. At last it did all go to pieces.

Mr. HUNT. It was fired several hundred rounds without any difficulty.

General BENÉT. I think it went up to 150 rounds at first. It must have been fired 200 rounds; but the steel tube cracked.

Mr. HUNT. If that steel tube had been a homogeneous mass of cast iron the question is whether it would not have kept together.

Senator HAMPTON. Did not the cracking of that steel tube practically weaken the gun?

Mr. HUNT. Of course it weakened the gun.

General BENÉT. It weakened the outside.

Mr. HUNT. I should like to say a few words more about commencing the building of a plant for the manufacture of heavy ordnance and heavy projectiles for the government use. It is evident enough that sooner or later that must be done in this country unless it is believed that individuals will start out in that direction, and the record of the foundries in this country that have had work for the government will not warrant any such risk. The fact is that the foundries employed by the government have been brought down to the lowest point, just on the verge of bankruptcy, for want of patronage. There has been no patronage for the last fifteen years that has been worth having; it has all been experimental work, which is costly and not remunerative at all to the foundries. Our machinery has been idle three quarters of the time for the last fifteen years. There is no encouragement to warrant any new concern in starting in unless it should have a definite promise from the government, and the longer this is delayed the more risk we take. It is like mercantile houses going on without any insurance, when the fire comes it will be impossible to get the insurance. It is high time some commencement were made. Whatever may be wise and proper is for you to say, but some commencement in that direction should be taken with a view to give such facilities as are creditable to this country.

JANUARY 27, 1883.

PROPOSAL OF SOUTH BOSTON IRON COMPANY.

Mr. TIMOTHY DAVIS. I ask leave to present papers prepared by Mr William P. Hunt, president of South Boston Iron Company and of the South Boston Iron Works, The latter firm name is to be substituted for the former in all future contracts for ordnance and other work to be done at the old foundry.

The papers herewith submitted contain much valuable information, and will be interesting to persons interested in the subject to which they refer. Mr. Hunt's general views are quite fully expressed in the remarks made verbally to the committee, and if what is now submitted is deemed to be too voluminous to be printed, I shall be satisfied if the letter addressed to the chairman of this committee by Mr. Hunt is made a part of the printed record.

OFFICE OF THE SOUTH BOSTON IRON COMPANY,
Boston, Mass., January 25, 1883.

Hon. J. A. LOGAN,
Chairman Select Committee on Ordnance, Washington, D. C.:

GENTLEMEN: The undersigned respectfully represents that the South Boston Iron Company has manufactured ordnance and war material for the United States for upwards of forty years, during which time it has executed all of its contracts with the government with exactitude and at reasonable rates, and in instances at positive loss and inconvenience.

That the close of the war, seventeen years ago, left our coasts inadequately protected, and that since that time the power of ordnance has steadily developed; and, although this increase of power is largely due to improvement in the ammunition rather than in the guns, we are nevertheless relatively much weaker than ever before.

That the experience of this company, and long attention to the subject of ordnance as a specialty, have not unnaturally suggested to its engineers and mechanics important improvements; but the company has hitherto confined itself strictly to the manufacture of such guns as might be adapted by established authority, and has rarely urged any plans of its own.

That, before the recent Board on Heavy Ordnance, this company presented views in some detail upon the subject, with plans of gun construction, and recommendations as to such a programme of construction and proof as was felt would be of most practical and immediate benefit to the government.

Congress having appointed your honorable committee to revise the proceedings and recommendations of this Board, the South Boston Iron Company presents in this form for the use and greater convenience of your committee a *résumé* of its several communications to the late Board and to the recent Committee on Naval Affairs; and, as president of the company, I unite with many others in the expression of an earnest hope that your committee may recognize the wisdom of such an appropriation as will enable the Ordnance Department to carry out the recommendations of the Board on Heavy Ordnance on such a scale as shall be certain to establish one or more patterns of heavy rifled guns which

shall prove to so far meet the imperative demands of our coast defense as to resolve all doubts as to the best direction for immediate efforts.

Although the drawings before the Board are voluminous, and from various sources, yet many are but slight modifications of each other; and a review only of those plans which appear to have engaged most attention from the Board, and received either partial or unanimous approval, is here given. All are breech-loaders.

1. Cast-iron rifles embodying certain improvements of design and mode of manufacture. Presented and advocated by the South Boston Iron Company, and by Col. T. T. S. Laidley, Ordnance Department, and others.

(Approved by two members of the Board.)

2. Cast-iron rifles re-enforced on the exterior with steel bands, after the Italian plan. Presented by the South Boston Iron Company and the Ordnance Office.

(Plan of Ordnance Department approved by the Board.)

3. Cast-iron rifles re-enforced on the exterior with steel bands, and also on the interior by a steel tube, after the French plan. Presented by the South Boston Iron Company and the Ordnance Office.

(Plan of Ordnance Department approved by the Board.)

4. Cast-iron rifles re-enforced by an interior tube alone. Presented by South Boston Iron Company.

(Not approved by the Board.)

5. Cast-iron rifles re-enforced with steel wire wrapped about the exterior as far as the trunnions. Presented by Col. T. T. S. Laidley, W. E. Woodbridge, the Ordnance Office, and the South Boston Iron Company.

A 10-inch (Woodbridge). Approved by the Board.

6. Various rifles built up entirely of forged steel. Presented by the South Boston Iron Company, W. E. Woodbridge, and others.

Design of S. B. I. Co. Approved by the Board.

7. "Wire guns" (so called) having steel tubes or bodies upon which steel wire is coiled under tension. Presented by W. E. Woodbridge (original), the South Boston Iron Company (modifications), the Ordnance Office (Armstrong), and Col. S. Crispin (Schultz—French).

A 10-inch Woodbridge (No. 1).*

A 10-inch Woodbridge (No. 2).

An 8-inch Armstrong (Ordnance Office).

An 8-inch Schultz (Colonel Crispin).*

Approved by the Board.

The presentation of the above designs will be recognized as coming from those sources only where special study and long consideration of these questions have been entertained. These various plans were submitted to the Board, in most cases, without previous knowledge of other plans under advisement (at least so far as this company was concerned); and the foregoing summary will perhaps serve to show the committee that there is not so wide a diversity of opinion, as has sometimes been claimed, among those supposed to be best informed as to the course which experiments should take to settle the question of a proper armament for our forts; the difference of opinions being mainly as to the *relative* importance of the various plans which it is generally thought should be tested. Certain radical differences as to facility of construction and quality of material of course obtain; and one notable exception to the general harmony of views above referred to may be mentioned. For

* Not unanimous.

example, the advocates of the importance of testing our best American cast iron to ascertain its exact value for use in gun construction are not only favorable to, but are absolute advocates of, wide-spread investigation in other directions; but, on the other hand, the advocates of various special plans, while apparently favorable to a liberal policy, are yet singularly averse to seeing any effort made to arrive at a true estimate of a material (cast iron) which it is nevertheless proposed to employ as a principal factor in designs for heavy guns.

The within communications to the Board will make clear our strong convictions upon the important question as to the character and extent of the tests which are most urgently called for in the present need of the country.

Briefly stated, our position is this: Liberal encouragement should be given to every intelligent and well-recommended plan to better our condition of defense. We should not be behind other nations in our efforts to obtain the most powerful guns; but, in thus striving after the highest results, we should not lose sight of present needs. Granting to recent "high-power" guns all that is claimed for them (and it is scarcely honest to claim for the guns what may justly belong to the improved character of the ammunition), there are many positions in our principal harbors where such guns could render no more efficient protection than guns of less cost and pretension. Other nations can better afford to incur the delay incident to such experiments, since they are already provided with guns of certain established power and efficiency. Nevertheless, they never allow any promised improvement to tempt them into inactivity, nor adopt the unwise and even dangerous argument which has been urged, that by waiting we might benefit by the researches of other nations. Therefore, our propositions to the Board on Heavy Ordnance may be said to be of two kinds. First, and most important, the construction of several great guns (at least three), the test of which shall prove whether we have within our own resources the means of constructing efficient heavy guns—especially important in an emergency—and, if not, then the degree to which we are at present dependent upon a foreign market for gun material, and the precise prospect of our future independence in this regard. Second, another order of experiments looking to the attainment of the most advanced results in gunnery. These two programmes in no wise interfere with each other; and success in the first would prove the first great step towards the protection of our seaboard cities, and security from possible national humiliation, and thus leave us free to pursue any deliberate and well-considered plans for still further strengthening our condition of defense and attack. This eminently practical view is adopted by the Board in the following language, when referring to the Italian and French plans of re-enforcing cast-iron guns with heavy masses of steel.

1st. Experience thus far gained with similar guns promises for the combination success within usual limits of powder pressure.

2d. They can be readily and rapidly produced in this country without incurring the delay of sending to foreign countries for large masses of forged steel.

The great weight of the foregoing guns recommended for test is, however, objectionable*, and this Board would prefer such combinations of materials possessing the highest tensile strength as will produce with less weight a gun capable of giving the high velocities now sought for. But, while this latter class of gun is being developed through a series of careful and costly experiments, some cheaper gun, though of less power, susceptible of rapid production, in case of need, should be determined upon; so that the country may not be left entirely defenseless.

* The designs of the South Boston Iron Company for similar 12-inch rifles were about 30,000 pounds lighter for each gun. (See Plates VII and VIII.)

It is true that the statement thus made by the Board, that such guns "can be readily and rapidly produced in this country," is difficult to reconcile with that paragraph of the report in which "the forging of the large masses from which the rings are produced by boring that constitute the successive layers," &c., is spoken of as "involving a very expensive plant, a very slow and costly process which does not result uniformly in the attainment of a perfectly homogeneous metal."

The much more massive, uncertain, and costly *steel tube*, necessary for one of the guns above referred to, and also for all of the so-called wire guns, altogether escapes notice by the Board;* nevertheless, the principle is recognized, that we should not neglect to make the most of our present facilities in the effort to arrive at a useful and practical weapon, pending the long delay and tedious investigation involved in the solution of that other problem, how to produce guns of the highest attainable power for a given caliber.

Arguments were before the Board tending to make light of the difficulty and uncertainty attending the production of heavy steel forgings of a satisfactory quality; but we dwelt at some length on this point, and frankly stated, that while we could indorse our designs as superior in a mechanical sense, and guarantee the necessary excellence of workmanship, yet the merit of the gun must depend mainly on the quality of the material, of which we propose to employ the best that can be produced. Given a material of good quality, the gun of the fewest parts is to be preferred; but the anxiety of steel-makers to keep these parts reduced to a minimum in size, calls for some compromise on the part of the designer. From our designs of steel guns, the Board selected one containing but few parts, and recommended "a 10-inch gun after the same plan, instead of the 8-inch gun shown on the drawing." It is assumed that a necessary latitude will be given us in these details, keeping only in view the production of a gun of the greatest possible power for the weight.

Military engineers generally agree that the problem of the so-called "high-power" gun is as yet unsolved; and it is an undeniable fact, that the high velocities which have recently been obtained constitute far more a triumph of the ammunition than of the gun; that is, that the improved powder of the present time has given high velocities without unusual or excessive strain upon the gun, and therefore the ability of the gun to withstand a limited number of such internal pressures proves little as to the inherent strength of the gun itself. Let the same advantage be accorded to an improved cast-iron gun by the use of similar powder, and it is reasonable to expect results proportionally good; and

* We introduce a design of a so-called "wire gun" (see Plate XV) embodying certain improvements in detail, which at present we will not describe. This gun furnishes a fair example of the quantity of wire which it is sometimes thought necessary to employ to justify the title "wire gun" to be given to the structure. In this, as in the experimental Armstrong gun, the wire replaces only some of the lighter steel bands which usually constitute the exterior of such guns. The steel tube and heavy steel jacket are the *real* difficulties in steel-gun building, and, when we can produce these parts successfully in this country, the lighter bands or rims will certainly give no trouble, and we can elect between them and a like bulk of steel wire. It is the purest sophistry to refer to such a structure as a *wire* gun; while to argue, that because steel wire can be made in this country, therefore the wire gun can be manufactured within our present resources, is to be clearly illogical or disingennous. Experiments with steel and steel-wire guns should certainly be undertaken; and, if successful, every effort should be made to abridge the time which must elapse before we can be independent of a European market for our material; but we should not be persuaded into inactivity in other directions by any of the true arguments in favor of testing the steel and wire systems, least of all by statements which can scarcely be called coherent.

while it is not expected that a cast-iron gun, costing, say, $25,000, shall possess the power *claimed* for a gun costing three times this sum, and of slow and uncertain production, it is nevertheless insisted, that if the cheaper gun shall prove even moderately successful, it is a positive necessity in the present condition of the national defenses.

The best military authorities also agree that there are many positions on all extensive coasts where a gun of extraordinary range and power (in proportion to the caliber) would be money and power wasted. Positions which require defense, but where the range is limited from a quarter of a mile to three miles, are very numerous; and in such positions the penetrative and crushing effect of such a gun as we propose (representing a power in actual excess of the *average* power of the present armament of most countries, and equal to that secured from foreign guns of like caliber with their present adopted charges) will be fully adequate for the purpose; while such guns would prove valuable auxiliaries in *any* position, to high-power guns, should we ever possess guns of the latter class in any reasonable numbers.

The Engineer Board on Fortifications has declared the necessity for a number of one hundred tons guns for our principal harbors; that is, guns which shall throw projectiles of at least 1,500 pounds to 2,000 pounds in weight. How shall such guns be obtained? Krupp demands from $100,000 to $175,000 for such a weapon, and will not even at that price guarantee it; nor could any reasonable number of them be delivered short of a great many years. But should the comparatively inexpensive experiment which is here proposed meet reasonable expectation, it would doubtless prepare the way towards furnishing a useful class of colossal guns at rates too moderate too prove a drain upon the national exchequer, besides leaving us independent of a foreign market.

The company's designs before the Board, copies of some of which are attached herewith, comprise a number of alternatives as to weight and details; but the following are more distinctly recommended; omitting the one hundred ton guns, consideration of which we understood the Board thought to be premature in the present phase of the problem:

1. A 12-inch B. L. cast-iron rifle (Plate III., Design D).
2. A 12-inch cast-iron rifle with steel tube (Spanish plan).
3. A 12-inch cast-iron rifle banded with steel (Italian plan).
4. A 12-inch cast-iron rifle tubed and banded (French plan).
5. An 8-inch or 10-inch, all steel, B. L. rifle.

Of these designs we unhesitatingly considered the cast iron gun first in importance, for reasons made clear in the following pages, and which will be found epitomized on p. 77, in the letter to the Committee on Naval Affairs, hereto annexed. And inasmuch as the use of steel in connection with cast iron, if efficacious as a strengthener, must either be more so on the exterior or the interior, the French gun, which has steel both on the exterior and interior, was deemed the least important, although very interesting, as a test gun. The trial of guns 2 and 3 would determine whether steel is most advantageous as a tube or interior lining, or in the form of exterior bands; while the test of the pure cast-iron gun would determine whether either of these expensive applications was necessary or useful, and, if so, the precise degree of that usefulness. There is much diversity of opinion among engineers as to the strengthening power of steel when applied to cast iron, and some extravagant views can be quoted on this question.

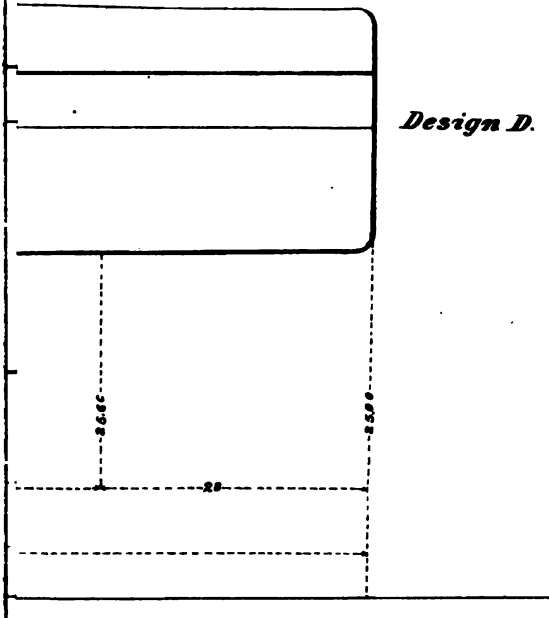
General Rosset, in an extensive series of experiments, demonstrated practically the superiority of the exterior over the interior application

Plate 3.

'ifle of 45 Tons.

So. Boston Iron Co.

Scale ½ 10 .



of steel to cast-iron cylinders; while General Virgile ("Memorial d Artilleria," 1882) concludes, from theoretical considerations—

That a single set of exterior bands would about double the strength of a gun; that a second set would further augment the strength about one-third; and that the steel tube-lining would more than quadruple the strength of a simple cast-iron gun.

If these speculations are anywhere near the truth, then the steel-lined gun No. 2 should certainly be tested. We can conceive that such conclusions have a basis of probability, just in proportion as the steel is assumed to be of superior, and the cast iron inferior, quality; in other words, to hold these theories correct, we should have to regard the steel as of the *finest quality*, and the cast iron as *pot metal*. But steel tubes and bands are not of high, but of low quality, and, as the late Board has just reported, are of "slow, costly production, wanting in homogeneity"; while gun-iron (cast) of 30,000 to 40,000 pounds strength is *not* pot metal of 6,000 to 10,000 pounds tensile strength. In our calculations we must deal with material as we find it, and not as we would have it.

Of the foregoing designs or classes of guns, the Board recommended three—the third and fourth from the Ordnance Office and the fifth from our works. The first, *i. e.*, the pure cast-iron gun, which, from many points of view, was considered the most important of the series as a test gun, failed of a majority vote on the Board, two of the five members voting in its favor, for reasons assigned as follows:

1st. The experiment would not be costly, and there are improved methods of casting claimed to remove certain weaknesses inseparable from cast-iron guns.

2d. Powders and projectiles have been improved to give more uniform results and less destructive effects on guns.

3d. It is only by actual test of a large gun under these improved conditions that the suitability of cast iron for heavy ordnance can be known, and its comparative merits with other metals and systems of gun construction determined.

4th. The trial of a cast iron gun, pure and simple, may furnish useful information in regard to cast iron in combination with other metals.

It is thought that the above reasons given by the two ordnance officers on the Board cannot be successfully met by any objections, least of all by the narrow question of economy. It has been truly said that "the mere fact that other nations do not use cast iron exclusively in gun construction is no reason why we should remain in ignorance of its true merits in this country." The numerous arguments which have been advanced in support, both on practical and purely scientific grounds, of the thorough test of American cast iron under the conditions offered by the improved ammunition of the present day will not here be repeated; attention is simply drawn to what has been said upon the subject in the following pages.

In conclusion, we present to your honorable committee the following propositions:

1. We have thought that the Ordnance Department should be authorized to substitute the foregoing five guns for the four 12-inch breech-loading rifles which constituted the basis of a contract with the South Boston Iron Company year before last, and which contract the government has suspended through no fault of the company, and to its serious disadvantage. The contract price of these four guns was $46,000 each, and we would agree to construct the five suggested substitutes for a less aggregate sum.

That is to say—

One 12-inch rifle of American cast iron, as proposed (Plate III) and recommended by two members of the Board	$26,000
One 12-inch rifle, after the Italian plan, as recommended by the Board	40,000
One 12-inch rifle, after the French plan, as recommended by the Board	44,000
One 12-inch rifle, after the Spanish plan, having a steel tube only	31,000
One 10-inch all-steel breech-loading rifle, as recommended by the Board	35,000
	176,000

The superiority of the above designs to those which constituted the basis of our contract can scarcely be questioned; three of them, as has been stated, have been recommended by the Board, and the fourth received the recommendation of two of the five members.

2. The South Boston Iron Company can ill afford at present to undertake, at its own expense, the fabrication of a rifle of 100,000 pounds weight. At the same time, such is our confidence in the serviceability of the gun we would make, that we offer to furnish, free of cost to the government, a 12-inch breech-loading rifle of American cast iron, of the design D, Plate III, and guarantee that it shall successfully endure one hundred rounds with charges sufficient to produce a power of 9,000 or 10,000 foot-tons energy, equal to the penetration of about fifteen inches of iron armor; this being the established power, with battering-charges, of the great majority of weapons of the same caliber abroad at the present time—guns of higher power being yet in the experimental stage. Should the gun be thus successful, not otherwise, we shall be paid $30,000 for it, and a contract be given us for one hundred additional similar guns at $25,000 each, and one hundred projectiles per gun at prices heretofore paid; all to be furnished without delay.

And we beg to submit that justice to ourselves and an impartial consideration of the public interests warrant the acceptance by the government of one of the foregoing propositions.

Very respectfully, your obedient servants,

THE SOUTH BOSTON IRON COMPANY,
WM. P. HUNT, *President.*

PROPOSAL OF CHARLES PLAGGE.

Mr. CHARLES PLAGGE. I desire to present a proposition.

The CHAIRMAN. State your proposition.

Mr. PLAGGE. I will read to you what I have put in writing.

WASHINGTON, *January* 19, 1883.

To Hon. Senator JOHN A. LOGAN,
Chairman of Committee on Ordnance:

SIR: The undersigned respecfully submits the accompanying papers and drawings relating to the construction of heavy ordnance and comprising the following improvements:

1st. An improvement in the construction of the barrel of the gun, increasing its strength and equalizing the strain thereon.

2d. An improvement in the devices for loading and cleaning the gun at the breech.

3d. New device for elevating the gun and checking the upward throw of the muzzle when the gun is fired at a high elevation.

4th. An improved recoil check for taking up the recoil and returning the gun to its former position automatically.

5th. The construction of an improved armor fastened to the gun carriage for the protection of the men working the gun.

In the accompanying drawing, Fig. 1, is a side elevation of the gun mounted upon my improved carriage for battery, bow, or stern guns, with the loading mechanism in readiness for loading.

Fig. 2 is a longitudinal horizontal section of gun-barrel in line I, II of Fig. 3, showing the construction of the gun-barrel.

Fig. 3 is a longitudinal vertical section, center of cylinder P, in line III., IV. of Fig. 1, illustrating my hydropneumatic recoil check for the gun, the latter being illustrated as mounted upon a pivot.

Fig. 4 is a traverse section in line V, VI of Fig. 3, showing the pressure chamber and channels by which it is connected with the sliding cylinders bearing the gun trunnions and valve arrangements for regulating the recoil.

Fig. 5 a traverse section through the gun-barrel in line VII, VIII of Fig. 3.

My gun is constructed entirely of steel, with an inner tube, divided longitudinally into two or more lengths or sections A^1, A^2, A^3, so that the breech end section, embracing the powder chamber, may be removed when worn, and replaced, leaving the outer lengths A^1, A^2 in the chase of the gun intact. These tubes are made of steel, compressed and forged by hydraulic pressure and to taper on their outer surface from breech to muzzle, and are reinforced and built up thereon as follows:

The inner tubes A^1, A^2, A^3 being joined by coupling a, a^1, two steel hoops or flanges, b, b^1, are screwed or shrunk on to said tubes, one (b) near the muzzle, and the other, b^1, near the breech end of the chamber.

The tubes A^1, A^2, A^3 thus mounted are placed into a machine which admits to turn about its axis. The apparatus, provided with suitable attachments for regulating the strain, being slowly turned, steel wire drawn square with the corners slightly truncated, is wrapped upon the tubes in successive layers over the whole length of the tubes comprised between the two flanges or shoulders b, b^1 until the wire wrapping at the muzzle end of the gun has attained the desired thickness and outline, when the steel casing tube B^1, to which is attached, at its forward end near the muzzle, the muzzle-piece C, and at its rearward end the shoulders s, s^1, is driven over the wire wrapping until the inner shoulder of the muzzle-piece butts or comes into contact with the muzzle end of the inner tube A^1. The shoulders s, s^1 of the casing tube B^1 are formed by shrinking, welding, or riveting reinforcing hoops to the casing tubes. When the latter is thus put into position, the wire wrapping is continued until the outside lines of the wrapped barrel correspond with lines drawn from the extreme outside points of shoulder or flange b^1 to the extreme rearward point of shoulder s on casing tube B^1. When this is accomplished the accurately-fitting casing tube B^2 is drawn over it until the shoulders upon the inner end of the tube B^2 strike against the counterpart shoulders s, s^1 on the outside end of tube B^1. The breech piece D is then screwed into a threaded seat formed in the rearwardly-projecting end of the outer casing tube B^2 until it strikes the rear end of flange b^1. Said breech piece D is further reinforced by the piece E, which is provided with flanges E^1, which connect by straps F F (Fig. 3) with the trunnion bars g, g, which are welded or riveted to the casing tube B^2. The outer casing tubes B^1, B^2 are made of steel plates rolled under hydraulic pressure and welded or riveted together in one piece, or made into two half cylindrical parts with dovetailed joint flanges

capped over by the trunnion bars g, g (see Figs. 4, 5). L (see Fig. 1) is a crane projecting rearwardly from the gun carriage over the breech to support a pully L^1 over which a wire rope L^2 is led from a drum H upon a crank shaft H^1, and by which the projectile and charge is raised for loading the gun. The projectile, when lowered by crane L, is deposited in a semi-cylindrical receptacle m, projecting rearwardly from the breech end of the gun, and supported upon a bracket hinged to the breech piece of the gun, as shown in Fig. 1. Upon being deposited in said receptacle m, the projectile is pushed forward, together with the former by attaching the crank to shaft f (not old), which has a pinion working in a rack on top of brackets, and thereby pushes the projectile, together with receptacle m through the breech and into the chamber of the gun as far as the receptacle m will enter into it; after which, by turning the removable crank (f^1) (bearing a drum, not shown), the projectile is driven home by the plunger m^1 upon the end of a tube, m^2, working through suitable bearings in the outer end of the receptacle m. This rod may be worked back and fourth by means of a chain or wire belt (m), whose ends are attached to the opposite ends of the rod, and are led to a drum upon crank shaft O^1. By turning in one direction the loading rod or tube m^2 will be carried in towards the gun, and by its revolution in the opposite direction the rod will be withdrawn. The outer end of the tubular loading rod may be connected by a coupling to a flexible tube connected with a steam boiler, so as to introduce a jet of steam into the gun to cool or clean it whenever wanted.

Connected with the loading apparatus for guns of large caliber is a detachable platform for the men loading and working the gun to stand upon. Both platform and loading attachments may be turned sideways whenever desired, thus leaving the rear of the breech end of the gun entirely unobstructed.

The frame of my improved gun-carriage may be constructed of any approved pattern adapted to support, in suitable ways, formed upon the top of the frame, and on either side thereof cylinders P P, which are arrranged to slide freely back and forth in said ways. A rod, R, Fig. 3, is led longitudinally through the center of each cylinder, its ends being firmly fixed in strong blocks on the frame. Its joints with the ends of the cylinder are properly packed to be air and water-tight. A piston, S, adapted to fit closely in the cylinders, is secured upon the rod R, so as to be immovable thereon, and in such a position as that, when the gun is at rest, itshall bear against the rear end of the cylinder. The rod R is made tubular from the point of its connection with the piston outward to its front end, where it connects with a lateral tube or condict, R^1 (see Fig. 4). This lateral condict is formed in the block supporting that end of the piston rod, extends downwards therefrom, and connects by means of a transverse tube, W, with an accumulator or pressure chamber, P, secured in the lower part of the carriage frame, and which is arranged to encircle said tube W. The latter connects the lateral tubes R^1 on each side of the gun-carriage with each other as well as with the intermediate chamber P. The opening therefrom into the pressure chamber T is governed by means of a concentric or tubular valve, V, which may be operated from without by means of a valve rod, V^1 (see Fig. 4). The pressure chamber T is fitted with a lateral cork, T^1, through which it may be charged as required with water, air, or other fluids by means of a small force pump, as shown in Fig. 1.

Communication is established between the tubular portions of each rod, R, and its appropriate cylinder by means of one or more apertures, Y (see Fig. 3). In the operation of the improved recoil check thus con-

structed, the cylinders and tubes are filled with water or other liquid, and kept charged as required by means of a body of air compressed by any suitable means into the pressure chamber T, and therein confined to bear upon the body of water which partly fills the same. When the gun is fired, the cylinders P P, which support its trunnions, are forced backwards, the pistons S S thereby compressing and forcing the liquid in front of the pistons out through the tubular rods R R and lateral tubes R^1 R^1, into the pressure chamber T. The resistance thus offered to the recoil of the gun is controlled by the size of the port or aperture through which communication is established between the connecting tube W and the pressure chamber, said port being regulated at pleasure by means of the valve V. A certain elasticity is imparted to the resisting medium by means of the volume of compressed air in the pressure chamber, which also serves to return the fluid to the piston cylinders when the gun is moved back to its normal position. The recoil being taken up by the resistance of a column of fluid which is brought under perfect control, with the utmost nicety of adjustment, by the simplest possible valve arrangement, no injurious strain whatever will be transmitted from the cannon to the frame, or to its platform, carriage, or pivoted support. Hence the heaviest cannon, when supported upon the recoil cylinders P P of my recoil-checking apparatus, may be safely mounted upon a pivoted platform or turn-table, as shown in Figs. 3 and 4.

When guns, especially long, rifled, high-power guns of modern construction, are fired with greatly elevated muzzle, the breech of the gun will be raised, and come down with a considerable blow on the groin or elevating screw. To counteract and control this injurious strain upon the elevating gear, I connect, when the gun is in the desired position or elevation, the rim of the elevating wheel Q, Fig. 1, by means of a pin or bolt g^1 to the head of the piston rod x^1 of cylinder x^2. The latter, parallel to the axis of and attached to the cylinder P, communicates by a channel or opening, x^3 (see Fig. 6), with the interior of cylinder P, and, consequently, by means of channels R^1 and tube W (see Figs. 3 and 5) with the pressure chamber T, so that the breech end of the gun, when the latter is fired, has to overcome not only the preponderance, but also the hydropneumatic pressure exerted upon the piston (x) of cylinder x^2 (see Fig. 6). To control the return of the breech end of the gun, after its upward movement has been checked, to its former position I connect the end of cylinder x^2, not in communication with opening x^3, by means of a tube or channel x^5 with the bottom of the reservoir x^4, containing water, and attached to cylinder x^2, so that, when the piston x is forced back against the hydropneumatic pressure exerted upon it, the vacuum created on the opposite side of the cylinder will be filled up by the water contained in reservoir x^4. The piston x, therefore, can return to its former position only gradually and in measure as the water in front of piston x can be forced back into the reservoir x^4 through the tube x^5, controlled by a valve, x^6.

For the protection of the men working the gun from the shot and shell of an enemy, I secure upon the frame of the gun-carriage (see Figs. 1 and 2) steel armor plates, n, projecting from the gun-carriage rearwardly upon an incline, its rear end being sufficiently elevated and extended to give the needed protection. The armor so constructed, even if of comparative light steel or compound metal plates, will constitute an almost invulnerable shield for the men serving the piece, as shots from the enemy can strike it only at an acute angle, such as will cause their ready deflection. Directly over and below the gun-barrel an opening of a width slightly exceeding the diameter of the gun-barrel at point

of intersection is cut in the armor to allow the gun to recoil; but this opening is covered by sliding plates, n^1 (Fig. 1), supported upon rollers, n^2, so as to play back and forth automatically in unison with the movement of the gun, and thereby constantly protects the opening, keeping it closed in whatever position the gun may be placed.

The ammunition for the gun is stored and served as required from a bomb-proof vault or chamber immediately below the gun (see Fig. 1), and which affords full protection to the men placed there.

Guns mounted *en barbette*, as shown in Fig. 1, or upon a pivoted carriage, as shown in Fig. 3, can thus be fully protected at the expense of least amount of steel armor, which, so applied, can also be easily put on or be removed from the carriage whenever so required.

To make steel tubes of great strength and reliability I cast the molten steel under pressure into molds, the vents of which communicate with a vacuum pump or ejector, which extracts the gases accumulated in the molten metal and pores of the mold, while the pressure exerted upon the surface of the molten metal at its inlet assists materially the removal of the gas. By this improvement in the casting of tubes I secure greater strength and reliability for same. The tubes thus produced are then forged or rolled by hydraulic pressure and special machinery invented by me. Submitting the above-described improvements in the construction and manufacture of heavy ordnance and gun-carriages to the consideration of your honorable committee, I beg to state that I am willing to give any further information whenever so desired, and respectfully sign,

CHARLES PLAGGE,
Care of David A. Burr, Attorney, Inventors' Institute,
Cooper Union, New York City.

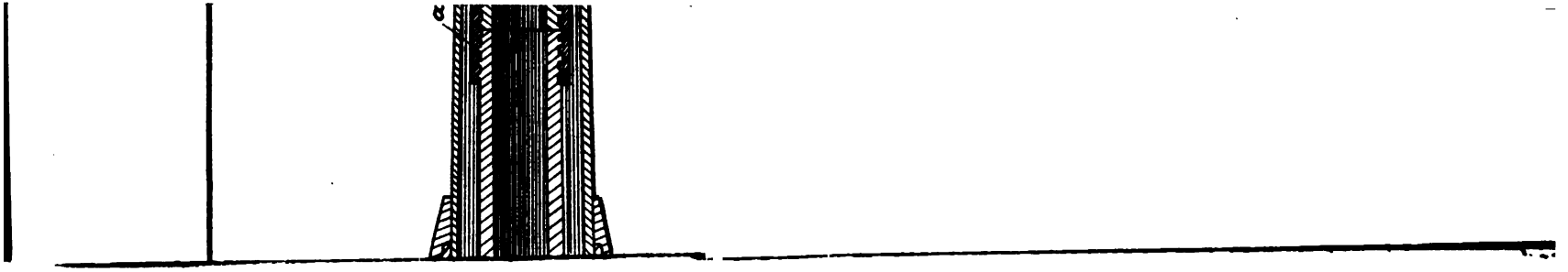
The construction is such that the breech section of the interior tube can be renewed when it is worn out without disturbing the whole gun, because that is the part of the gun which is more liable to wear out than all the others. Wire is encased in the steel tube. The steel tube I construct in such a way that it is steel-welded in the way I show in the drawing. That is as regards the construction of the barrel of the gun.

Another difficulty with the modern high-power gun is to overcome the recoil of the gun. For that I use a hydrogrametic recoil-check, which operates very simply. It is shown here in the drawing. The trunnions of the gun are supported on two cylinders, which move in ways on the top of the gun-carriage. These cylinders connect with a pressure-chamber, which is shown in the drawing. This chamber is filled with water, and there is compressed air. The compressed air forces the water into the cylinder, so that when the gun is fired and the recoil comes up the gun works against the pressure which is exerted from the pressure-chamber against the head of the piston on the cylinder.

The main point of my improvement is the easy regulation of the recoil by a valve which is set in the pressure-chamber. I have it fully described in the paper which I have presented.

Another point is the shield to protect the men working the gun. The shield is supported upon the frame of the gun-carriage; it is of steel; it moves around with the gun, so that comparatively a very small amount of steel is required to give protection to the men. The shield only extends to this point [indicating], but it can be extended, of course, as far as may be desired.

The third point is the facility in the loading of the gun. The shot is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dropped down in the receiving-box; this is pushed back up to this point till it touches there [indicating], and when that is touched the loading-rod pushes in the shot to the exact point where it is wanted. That is effected by the turning of the crank. The rammer is connected with both ends, so that by turning in one direction it moves the shot in, and turning the crank in the opposite direction it takes the rod back. The rod is hollow, so that whenever it is necessary to clean the gun there can be screws fixed to it and the steam blown through it, so that the gun cannot only be cleaned by this means, but also it can be cooled down when it gets, by quick firing, too hot.

Then another arrangement is that it is mounted either on a pivot, or as I have shown it on the drawing. Krupp has constructed pivot-guns of similar use, but he has no recoil-check. He has the gun-carriage connected with the pivot, and there is an immense strain on the pivot, but in this construction the entire recoil is taken up by the recoil-check, so that there comes no strain on the pivot.

STATEMENT OF A. H. EMERY.

Mr. EMERY. The subject of heavy ordnance and projectiles is one that I have spent, in the experimental work of, and in studying, something like four years, and that is independent of a good many years study which I have had in other branches of work, all of which has helped me to gain a pretty extensive knowledge of the strength and properties of materials. The question of heavy ordnance is a difficult one in the minds of most men, and in the present case is enshrouded with a great deal of difficulty in that so many systems are offered by so many men, each of which think they understand all about it. Many of the plans offered are purely chimerical, the inventors seldom being mechanics. While there are some mechanics and engineers among those that have offered plans or models, their percentage is small.

The ground I take is the same that we have found in testing other engineering works, where tests of small pieces in small machines show strength of metal which do not apply to large forgings and large masses put together for actual service. To illustrate this I would mention that some 6-inch steel bolts were tested where in no instance did they reach a tensile strength, when tested as a whole, of 40,000 pounds to the square inch, but repeated tests of small pieces cut from these same bolts subsequently bore loads of never less than 90,000, and most of them from 110,000, to 120,000 pounds per square inch. This showed that the bolt was under initial strains up to fully two-thirds the load for rupture; so that to know the strength of that bolt, to test a little piece of it was utterly delusive. To know the strength you must test the whole piece. By testing bolts and links and columns in the machine at the arsenal we have found that the supposed strength of them was very different from the real strength; and engineers to-day of the three classes, civil engineers, mechanical engineers, and mining engineers, have fully concluded that actual tests of working parts must be made to show their strength.

Now, in the case of guns, the gun is made of pieces of cast iron and steel, or wrought iron and steel, or wrought iron alone, or cast iron alone, or cast-iron and steel bands, or cast-iron and steel wire, or steel barrel and steel wire; but, with the single exception of small guns,

which are made of one piece of steel and, small and large, of one piece of cast iron, they are all made of built-up parts. Many of those, on the face of them, appear to be good and strong combinations. In going before the Board of Heavy Ordnance in New York, I stated that I had several systems of guns new in method of combination, that is, in the method of combining the parts, and in the method of making those parts previous to combining, and in the method of assembling those parts. Others had plans. The Ordnance Department had several plans, and I proposed that from those plans six be selected, such as should seem to be most desirable to test, and drawings made of them, to bring them all to one common standard; then sections made representing sections of different parts of those guns, all made to a similar scale, and breech models made of each of those six systems; and that of those breech models two of each be put into the machine and tested, to know the actual strain at which they burst, and that two of each be tested with powder, to see how far the powder test would correspond with the machine tests; that of the sections, two of each be made and put into the machine and burst, so that we might know the actual pressures which they would stand. Then, when we had tested the six systems, we would know their actual strength, and we would know the relative strength of each of those six systems. And if to these we added similar tests of the four foreign systems which have gone into general use, the Krupp, the Woolwich or the English gun, the Italian gun, and the French gun, we should then know not only the strength of the guns which we proposed to make absolutely and their strength relatively, but we should know the absolute and relative strength of these four principal foreign systems, and their strength as compared with those we are making and propose to make.

The result was that the Board selected ten systems for such tests, and employed me to make drawings of them. These systems were the Ordnance gun which was then under contract, the 12-inch rifle, another Ordnance gun which was proposed, a cast-iron gun, three systems of my own construction, the English, the French, the Krupp, and the Italian; and they employed me to make drawings of those, with the estimated cost of the expenditure necessary to make the tests of those ten systems. I asked if there was any other system they cared to include in addition to those ten. They said there was not. I then proceeded to make the drawings, bringing all the bores to the length of the English 12-inch rifle, which is the same as the American then under contract, namely, 26 caliber. The guns with 26 calibers were considerably longer than the French and Italian guns of that caliber, and they had to be brought to a model of the same length to give relative comparison, and in doing that the sizes or proportions of the French and Italian were brought to corresponding sizes with the American and English, such as would be likely to be used if they were made. The Krupp gun selected for this was what is called the 30-caliber gun, which gave this same length of bore, that is, 26 caliber, by simply shortening very slightly, so that they were all prepared and proportioned to a length of bore of 26 calibers. This drawing illustrates the methods of making the tests [exhibiting]. Six sections are made, corresponding to two sections through the breech of the gun, through its powder chamber, one through the shot seat, and three through different parts of the chase, the sections in each gun being taken the same distance from the base of the bore, so as to give the corresponding strength in the same position in the different guns.

These sections are proposed, all of them, to be of 8 inches diameter

bore inside, and the same proportional diameter or thickness of walls as the gun would have at that place, and each are 12 inches long, so that they represent the true strength of the gun of 8-inch caliber at those positions which they represent of the model, corresponding in exact proportions to the 12-inch model. The breech models were made in the true proportion, one-third size, as the sections were two-thirds size. The bore would thus be 4 inches and the chamber 5 inches in diameter. These models thus would represent the true breech of the 12-inch gun made to a scale of one-third size. The estimated cost of each of these was given in detail to the Board, together with the weight of the parts and of the material of which they were composed.

The Board, on receiving these estimates, subsequently acted on them, and reported as follows:

In the opinion of this Board, much valuable knowledge would be gained for ordnance constructors and for the general ends of science, as to the relative effects of impulsive and continued forces, by a series of experiments of the nature set forth in this paper; yet, in view of the great cost (over $400,000), and of the delays that would be involved in carrying them out, they cannot be undertaken by this Board. It is, however, suggested that a limited number of trials be made in this direction with such models as will best tend to elucidate the subject.

I would now say that this Board have recommended, as we see, the construction of ten to twelve different guns. Past experience shows that no system of gun has ever been perfected or satisfactorily tested until a number of guns of a given size have been made, and for 12 inch guns usually two years has been allowed for the preparation and making of the first one; so that to perfect any one of these systems of 12-inch rifles in the ordinary way would take from four to eight years, with an expenditure of several hundred thousand dollars. If now we multiply this several hundred thousand, which must be taken at least as 6 or 8, by the number of guns it is proposed to test, we shall find a very large sum of money and much time expended before we should satisfactorily arrive at a conclusion of what is the best gun, if we proceed, as the Board has proposed, to make a test of 12-inch rifles of different systems, and finally select the best. If, however, we were to make the tests recommended by me, as per estimate proposed, while we should spend, say, $400,000 in selecting which of these systems was the best, we should know more of the art of gunnery, as to the true system of building up a gun, and of the real and absolute strength of those guns, than has been determined by Europe in spending four hundred millions of dollars. We spend from a half million to two millions on a war vessel and then throw it in the scrap-heap unfinished. I propose simply to spend four or five hundred thousand dollars to know how to make the best gun, or which is the best system of gun construction, and after we have selected the best system we may make 12-inch rifles on that system and determine, by actual firing, the most suitable charge for such a gun.

It has been stated by some that machine tests and powder tests are different things; but I would say, as an engineer, that while the powder test endures in the gun with a maximum pressure only for a very short part of a second, in the machine the test endures often for hours before the specimen is burst, and those systems which may be selected by the machine which are shown to endure the tests for hours certainly may be expected to stand the test for a fraction of a second, while those systems which the machine shows have not strength to resist large pressures any length of time certainly offer poor inducements to put into the hands of the Army and Navy to defend ourselves with. So it would seem to me vastly more economical of time and money to proceed with

the use of the machine as a fit instrument to select the best system to test by testing these sections, and then make the guns actually required for service, and then find, having the best system, what endurance it has, and use such charges as are consistent with that endurance and the wants of the service.

The CHAIRMAN. Do you think that a machine test where the pressure would be used for an hour would be as good a test as a test where the whole force and power was instantaneous?

Mr. EMERY. In one case the pressure endures for a hundredth part of a second at a maximum, or less than that, and in the other case the piece has endured it for hours. If it will endure that pressure for hours, it must have endured it the small part of a second first, and repeated it many times to make up the hour, so that a model which will bear this pressure——

The CHAIRMAN. That is not the point; of course it endures it. What I mean is, whether, where a pressure is gradual, the resistance is not greater than it would be where it was momentary. Is, or is not, the power of resistance greater?

Mr. EMERY. The metal will bear, for a very short space of time, much more pressure than it will bear for a long time. For instance, the old powder pressures obtained in the smooth-bore with the quick powder formerly used were usually more than any of those guns could have endured for two minutes, and yet the gun might endure five hundred or a thousand fires before rupture. It would, in general, endure until the added times of these maximum pressures, through the repetition of firing, amounted to one or two or three seconds, and then the gun has burst. But with the testing machine we may find what the maximum pressure which the gun will endure is, and then see to it that our powder does not give more pressure than that which the gun is fit to endure for hours. In that case the gun would be permanently safe.

The CHAIRMAN. Is powder a thing that you can calculate upon at all?

Mr. EMERY. Yes, sir; we can make our powder of such density and such material that its rate of burning is pretty well controlled. That being the case, if the projectile put in the gun is of a kind which shall offer no obstruction other than that of its inertia to movement from the gun, and the packing resistance is such as to offer comparatively a few thousand pounds of friction, then the time which that gun will have to endure that pressure may be approximately well known, and the maximum pressure which that powder will give pretty definitely known; but if the projectile is of a kind which will wedge in the gun, so that the projectile instead of being propelled ceases to move forward, you may get an unknown pressure which will be sufficient to destroy a gun of otherwise safe strength.

The CHAIRMAN. As I understand your theory, would you say that testing a gun under the pressure of the testing machine, as it is called, would be a sufficient test without firing it?

Mr. EMERY. Be a sufficient test to select which of these systems was the strongest, but not a sufficient test of the system. I would select, for instance, from ten systems by the machine tests, two or three which showed themselves to be much stronger than any of the others.

The CHAIRMAN. You are speaking of the metal?

Mr. EMERY. Of the metal when put into the form and prepared in the way you prepare it for the large guns, preparing these sections precisely as the guns made from them would be prepared, so that they correspond to the sections of actual guns of those sizes. Then we determine the relative strength of guns on those systems of construction,

and when we know the relative strength, we would take those which were the strongest, and instead of testing ten systems with powder, we would select, by the aid of the machine tests, two or three systems as being the best, and then build our 12-inch guns on those systems, and see what endurance they had with the powder test. Instead of going to the expense of testing ten systems of large guns, we would go to the expense of testing one, two, or three systems. If one system showed radically more strength than the others, we would select that one and test it; but we may find that it is divided between two or three, as being much stronger than the others, and each having their point of excellence in strength or economy of construction.

In regard to the guns themselves, I would say that I have several plans of construction which seem to me, as an engineer, with my present knowledge of materials and ordnance, to possess such points of excellence that I do not hesitate one moment to say that I know I can make a better gun than has ever been made yet, and I know that I can proceed to make at once 12-inch rifles which will be good, but it is not probable that I would make the first 12-inch rifle as good as I would the succeeding one with more experience, but I certainly should be able to make a good one the first time.

The CHAIRMAN. That is your opinion?

Mr. EMERY. I know it as an engineer, and my opinion as an engineer is that it would be better than any gun that has been made. I know, as an engineer, it would be a good gun.

The CHAIRMAN. What material would you make it of?

Mr. EMERY. I would make it of cast iron and steel and bronze, or of steel and bronze alone, depending on which of the systems I selected. If I selected the system of cast iron and steel and bronze, shown on Plate 2 of my plans before the Board, I can make a 12-inch rifle with the present facilities in the country by importing simply one piece of metal, its barrel. We have no hammer in this country sufficient to make a lining barrel for a 12-inch rifle. If the number of guns ordered to be made were sufficient, then I would provide a hammer and make that lining barrel here, otherwise I should have to import it.

That is the single piece I should have to import to make 12-inch rifles under that system, rifles which I know would be good, rifles which would give very excellent work, but not so strong as one I would make of steel, if the whole breech chamber and breech of the body is of steel, which would require a much larger plant. That plant necessary, with the hammers, to make the 12-inch rifle, where the whole breech of the body is of steel, is expensive, more expensive than any one would be warranted in making without the proper assurances were given that appropriations would be made and a large number of guns purchased if the gun so produced proved to be the best gun that was made.

The CHAIRMAN. What assurance can one Congress give that another will do the same thing? You cannot have any assurance from Congress.

Mr. EMERY. It is exceedingly difficult. We must, therefore, as gun-makers, take our risk of doing the work which must be done with such a contract as one Congress is willing to give, taking our risk of another Congress following in its footsteps. If a system should be selected which I have proposed for the construction of a 16-inch rifle, a gun more powerful than any that has ever yet been made, a gun to take a service charge of 800 pounds of powder, with a projectile of 1,600 pounds, that system can be built in the same plant which would build the steel gun with a 12-inch breech of steel.

The CHAIRMAN. How much armor would that penetrate?

Mr. EMERY. At least three feet of wrought iron.

The CHAIRMAN. At what distance?

Mr. EMERY. At half a mile, and probably at a mile, with suitable projectiles. That gun can be made as a 12-inch rifle in the country at this time by the importation of two pieces of steel for it; that is, for the lining barrel and the chase. That system presents greater facilities for the working of very large bores than any other that is known to me—that is, for guns of great strength—without very massive tools for production. It would be quite as easy to make a 20-inch gun on that plan to burn 1,600 pounds of powder as to make the 16-inch Krupp gun, equally good, which is for a charge of about a third of that quantity of powder. The Krupp gun is the best known to the public to-day. It is a very strong, serviceable gun, but has very serious defects in its construction in that the part of the gun which constitutes the chamber and seat of the shot, which should be of the strongest and best metal in the gun, is of the very poorest. His forging for the body being made solid, the outer part is well condensed under the hammer, but the inner part is very poor and soft. The very poorest is bored out in making the bore and chamber of the gun, but the poorest which is left is next to the chamber, metal which is so soft that it often flows under the pressures which it should endure, and when it flows under the powder pressure it acts with the powder to burst that part of the gun around it. The exterior of Krupp's gun is of steel bands, which may be well tempered with oil and be made good, but this interior body is of such form and size for the large guns that it cannot as yet be well forged in its inner portions, nor has any process of tempering yet been put in practice by which a mass so large can be tempered. By making the guns of the form and construction I have proposed, the finished parts of steel which I have proposed can in every instance be well forged, that part which is not well forged being in every instance removed by boring, and they are of such proportional thicknesses to their size and form that they may in all instances be tempered in oil, thus giving us steel guns of much greater strength of parts before assembling than are provided in the Krupp gun; and the processes I have for assembling are such as to enable us to assemble them in such a way that the interior of the gun is under compression and the exterior under tension, properties which are extremely desirable in gun construction, as is well understood by all ordnance officers.

The CHAIRMAN. There never has been any test of that kind of gun. There has never been any gun of that kind made.

Mr. EMERY. No, sir.

The CHAIRMAN. Would you advise the government to make a contract for making guns of that kind without testing them?

Mr. EMERY. I would advise the government to do it on two conditions: first, that the party proposing the contract was known to be a man of good judgment and experience in the knowledge and properties of the materials of which he is talking; second, that he would take the risk of furnishing a good gun, as I did in the case of furnishing a testing machine.

The CHAIRMAN. As I understand you, there is no plant in this country calculated to make that kind of a gun?

Mr. EMERY. We can make, as I said, the 12-inch cast iron and steel gun which I propose, in this country, by importing simply the lining barrel, and we can make it more easily than any other gun that has yet been proposed of equal strength. That gun will be nearly or quite as

strong as Krupp's, but much less expensive to make. Those which I propose with entire steel breech-body made of built-up parts will be stronger than Krupp's, but those take a more expensive plant than the other, a plant which we have not, and which we should not be justified in making unless a contract for quite a large number of guns was offered.

While I have offered my own opinion as regards the quality of my guns and their processes of construction, I would like to hand two letters to the committee, or rather copies of letters, the originals of which I have, to show the opinions of other well known engineers as regards the quality of these guns—one, the letter of General Gillmore, a well-known United States engineer; and the other, of the late A. L. Holley, who was perhaps the best informed on gun-plants and their construction of any man in the world, he having repeatedly visited the various large gun-works, and having access to all of them at all times as few in the world had; and no other engineer has, to my knowledge, made such frequent and extended visits to various gun-works over the world as Mr. Holley.

The CHAIRMAN. Is General Gillmore the man who used to command in South Carolina during the war?

Mr. EMERY. Yes; and he burst a good many guns while there, and General Foster, who succeeded him, burst a good many more. I asked him what proportion that was of the guns they had, and he said pretty much all of them. He alludes in the letter to his experience with short-lived guns. He was the president of the Mississippi River Commission at the time he wrote this letter, and would be now except for retirement on account of ill health.

The letters are as follows:

UNITED STATES ENGINEER OFFICE,
Army Building, New York, July 21, 1881.

GENERAL: Knowing the interest you feel in everything relating to the efficient and economical defense of our sea-coast, I have taken the liberty of writing this letter for Mr. A. H. Emery, a distinguished mechanical engineer, who has given much thought to the subject of heavy guns.

I have known Mr. Emery for several years. He designed and built, a few years ago, for the United States Board for Testing Iron and Steel, of which I was a member, a testing machine of 400 tons capacity, which is admitted to be unrivaled in the world for perfection of design and workmanship. It gives the most accurate results under light as well as heavy strains.

Mr. Emery's designs for heavy guns, for new guns, as well as converting old smooth-bores into rifles, are remarkable as embodying the highest theoretical and practical knowledge of the properties and uses of the various gun-metals. His methods appear to possess every essential element of superiority.

My disagreeable experience with short-lived guns during the civil war has led me to regard with favor the efforts of all competent men to give us an efficient armament for sea-coast defenses.

I believe that guns built after Mr. Emery's designs and under his direction would meet all the requirements of efficiency, endurance, and cheapness.

I am sure it would tend to advance the public interests if you can afford him an opportunity to exhibit and explain his various designs.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieutenant-Colonel of Engineers, Brt. Maj. Gen., U. S. A.

General W. T. SHERMAN,
Washington, D. C.

NEW YORK, *July* 2, 1881.

GENTLEMEN: Mr. A. H. Emery will see you about interesting your company with him in the manufacture of guns on his plans.

I am thoroughly familiar with Mr. Emery's plans and with his qualifications as a mechanical engineer. As a member of the United States Test Board, I inspected, from time to time, the building and performance of the 400-ton testing machine that Mr. Emery built for the Watertown Arsenal. This is universally admitted to be one of

the most remarkable mechanical constructions in the world, and it establishes Mr. Emery's position not only as an ingenious designer, but as a successful builder of machines and structures that involve the highest formulated knowledge of materials and strains and the greatest familiarity with machine-shop details.

The successful manufacture of ordnance involves the same kind of theoretical and practical knowledge as that which Mr. Emery has so fully exhibited in the testing machine, and I can say with confidence that I know of few, if any, men who could make better guns, considered as mechanical structures.

As to the designs of Mr. Emery's guns (for many features of which I think he can secure valuable patents), I am of the opinion that they embody the great established principles of gun making in forms and methods which are superior to any others with which I am familiar, both as regards efficiency and cheapness. Since the publication of my treatise on ordnance and armor I have endeavored to keep posted on great-gun making by frequent visits to Woolwich and to Krupp's, and to other works abroad, so that I am, perhaps, warranted in expressing an opinion on the subject.

I have no doubt that the manufacture of ordnance on Mr. Emery's plans and under his general supervision would, if proper tools and facilities were provided, become a very large and profitable business.

Yours, truly,

A. L. HOLLEY.

Messrs. MACKINTOSH, HEMPHILL & Co.

The CHAIRMAN. Is there anything more you want to say?

Mr. EMERY. I do not know of anything further.

The CHAIRMAN. Do you make this as a proposition to the government?

Mr. EMERY. If you choose so to take it. I would add that the plan for all these machine tests, with the estimated costs, is in the hands of the Board and can be obtained at any time from them. I will undertake to make those experiments of all the systems there at the price there mentioned. I should not like to do it at a less price.

I would like these tests made, so that Congress might feel assured the models I have designed are not only excellent but much better than the service guns that have been made in Europe. For myself, I am fully satisfied, and if Congress will not make these machine tests, I would not hesitate a moment to take a contract to make these 12″ and 16″ guns in reasonable quantity, at a suitable price, to be based upon their quality, with the condition that no charge should be made for the experimental guns unless they proved to be good guns, although Congress has heretofore almost always, if not always, paid for the experimental guns, of which many have been built under the directions of the inventors thereof, in addition to the large number of trial guns the departments have built directly under the supervision of its own officers; and though the building of guns and plants to make them by the government has cost many years of time and some millions of dollars, not a single satisfactory gun has been produced in this country.

The plans which I put before the Board included plans for converting 10-inch smooth-bores into 8-inch rifles and 15-inch smooth-bores into 11-inch rifles, as well as the plans of new gun construction. The Board, however, decided that it was unadvisable to convert the smooth-bore 15-inch and 10-inch guns on any plan; that they had better be used as they were. Should the conversion of the 10-inch smooth-bores into 8-inch rifles continue they might be made much stronger under the plan I proposed than those being used, and they would give very serviceable guns with much higher velocity and greater durability than those heretofore converted. The expense of conversion would be more than that of the present system, but not so much more as the gun is better.

NORMAN WIARD.

Proceedings of the Senate Select Committee on Ordnance, Saturday January 6, 1883.

1. The CHAIRMAN. Mr. Wiard, have you any inventions in heavy ordnance to bring before us?

2. Mr. WIARD. I am not fully prepared, Mr. Chairman, to submit my proposals now. I have drawings and engravings in course of preparation. I desire at this time to read a review of the Nut Island experiments to the committee. I will present my proposals in a few days. With your permission, I will hand them in previous to your next meeting. I simply wish now to present to you what I have already done, and ask that it shall be considered. I have already conducted the experiments I desire to refer to, partly at my own expense partly at the expense of the government. I desire to show you how guns can be produced cheaply and quickly from stock on hand. I have already tested the most complete, powerful, effective, and reliable system that has ever been tested by any one. The results have been grossly misrepresented. I wish to put you in possession of the facts, as shown by the official reports and other testimony, that you may have fair opportunity to judge of its value.

3. The CHAIRMAN. Let us have it.

THE NUT ISLAND EXPERIMENTS WITH GREAT GUNS.

A REVIEW BY NORMAN WIARD.

"Facts are stubborn things."

4. The Nut Island experiments were authorized in the beginning by act of Congress approved May 23, 1872. The experiments were continued through the years 1873, 1874, and 1875 with such remarkable results as to attract the attention of experts throughout the civilized world; and although the firings terminated six years ago, and every military power has steadily continued to make enormous annual expenditures in efforts to increase the power of artillery, no real improvement has been made.

5. It is true that larger calibers have been adopted, longer bores tried, new complications have been added, increased expense has been incurred, but up to the present time not a single gun has been produced by anybody or anywhere in the world of the calibers, weight, or cost of the Nut Island guns which gives even one-half the power for the penetration of iron defenses, at long or short ranges, possessed by guns of the Wiard system if the same charge of powder and same weight of projectiles are used.

6. Further, there is not a rifle-gun of large caliber now on hand in the possession of the United States or any other government which cannot be more than doubled in power and greatly improved as to endurance by applying to it the Wiard system of rifling and adapting it to the use of the Wiard "centered," "mechanical fit," "spiral triangular," sub-caliber projectile, with a cutting point.

7. The *facts* officially recorded in the reports of the Nut Island trials show plainly that the above statements have solid foundation of truth.

8. The absence of the inventor in Japan for two years immediately following the conclusion of the Nut Island experiments afforded opportunity to disloyal officials, ignorant and designing persons, selfish and

unscrupulous rivals, forgers, thieves, and conspirators to cast a shadow of doubt over the results.

9. Even a casual examination of the *facts* officially reported will convince any sensible and unprejudiced person that the doubts thus created have no real foundation.

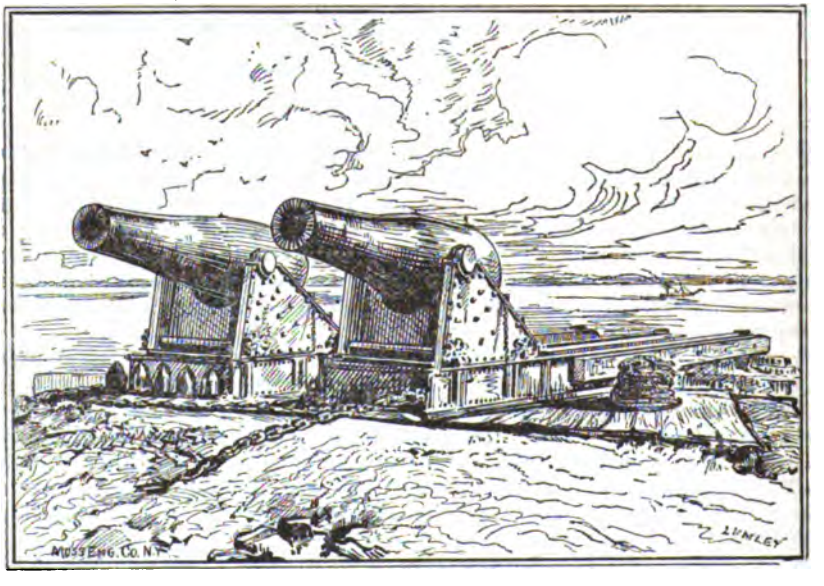
10. The Secretary of the Navy, in answer to a letter of inquiry addressed to him by the chairman of the Naval Committee of the House of Representatives (pages 16 to 121, inclusive, H. R. Mis. Doc. No. 170, part 9, Forty-fourth Congress, first session), said of the results:

11. The penetration of the projectiles invented and fired by Mr. Wiard in these experiments shows a result, both at short and long range, unequaled in the history of heavy ordnance, illustrating at once the correctness of his manner of rifling, and the fact that his projectile is the best yet invented for that purpose; and it is evident to any one that valuable data, recorded by the officers detailed to witness these firings, could only be obtained as the results of these or similar experiments.

12. And he further said:

13. It is true that the most remarkable results obtained were produced by charges of powder not exceeding and even less than those allowed by regulations for actual service, as, for instance, the penetration of 12 inches of iron at the distance of a mile with 70 pounds of powder, the regulation charge allowed for the same caliber of gun in battle being 100 pounds.

14. The experiments were inaugurated by preparing two new guns of 15-inch caliber, each weighing about 46,000 pounds. The guns were cast hollow and cooled from the interior. They were designed by General



THE GUNS BEFORE FIRING.

Rodman, and cast under his direct supervision. One was rifled on the Wiard plan; the other remained in its original condition, a smooth bore. They were mounted on like carriages and set up side by side, to be fired—according to the terms of the contract—with like charges and of equal weight of powder. The projectiles were of equal weight, one spherical and the other conical, centered, and mechanical fitting, and were aimed at targets—short range—each 15 inches thick.

15. The official inspectors present described the guns, as mounted, as follows:

Quotations from the general report of Capt. George Brown, naval inspector, on shots fired 28th November, 1873.

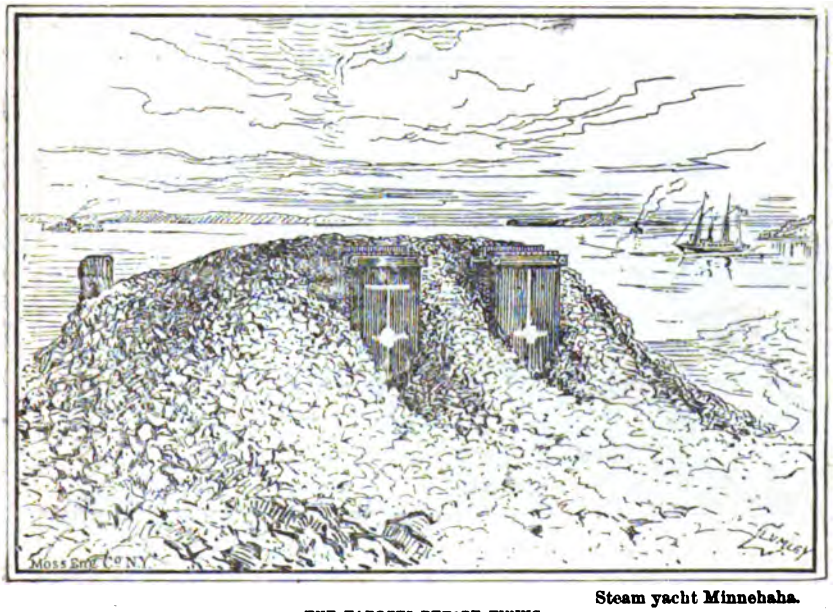
16. The guns mounted on Nut Island, in 1873, were two 15-inch guns, weighing 43,000 pounds each, made by the South Boston Iron Company, and a pattern differing somewhat from the army and navy guns of the same caliber. One was rifled on the Wiard plan, the other an original smooth bore. They were mounted on army carriages with slides lengthened so as to admit of excessive recoil, and were not provided with any means of restraining the recoil, depending only on the friction of the carriage on the slides.

17. Captain Truxton, in his report, used the same language in describing the guns and carriages.

18. Captain Brown described the targets as follows:

19. These guns were fired on the 28th of November, 1873, at similar iron targets, 15 inches in thickness, composed of five 3-inch plates, backed by frozen gravel, and distant 150 feet from the guns. The two guns were loaded with like charges of mammoth powder of 140 pounds each, the projectiles being of equal weight—450 pounds—that for the rifle being of the Wiard pattern, with chilled ogival point; the one for the smooth bore being a solid spherical shot.

THE TARGETS—THE NUT ISLAND ORDNANCE EXPERIMENTS, PLATE I.



Steam yacht Minnehaha.

THE TARGETS BEFORE FIRING.

Report of Captain Truxton, referring to shots fired on 28th November, 1873.

UNITED STATES NAVY-YARD, BOSTON,
Ordnance Office, November 29, 1873.

20. COMMODORE: For the information of the Bureau of Ordnance I have to report that Mr. Norman Wiard, yesterday afternoon, the 28th instant, fired one shot from his rifled 15-inch gun, the projectile being of chilled iron of the shape shown by the photographs in possession of the bureau, and weighing 450 pounds; the charge was 140 pounds mammoth powder, manufactured by the Oriental Powder Company of Boston.

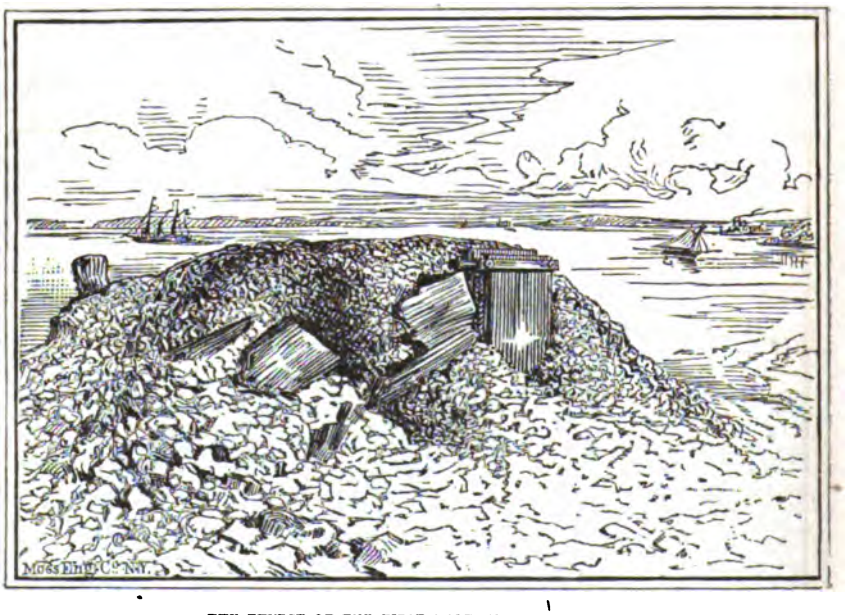
21. The target consisted of five plates, each of 3 inches in thickness, rolled from a pile of six half-inch plates, and prepared by the construction department of this yard. The target was in front of the butt and a backing of 10 feet frozen ground, and was placed at a distance of 150 feet from the muzzle of the gun; the plates were banded together at the top. Owing to the freezing of water in the gravel the plane of the target differed about an inch from the face of the muzzle.

THE RESULT OF THE FIRING.

Quotations from the general report of Capt. George Brown naval inspector, on shots fired 28th November, 1873.

22. The results of the firing were as follows: The rifle projectile perforated the five plates and was found in the frozen gravel very much distorted. The plates were driven into the butt, very badly shattered, and two large pieces sent flying through the air a distance of 50 yards.

THE NUT ISLAND ORDNANCE EXPERIMENTS, PLATE 2.



THE EFFECT OF THE FIRST SHOT—THE RIFLE GUN.

The target fifteen inches thick completely penetrated!
Twelve feet of frozen gravel—in addition—penetrated!

Projectile 460 lbs.
Powder charge 140 lbs.

Remarks of Capt. George Brown, U. S. N.

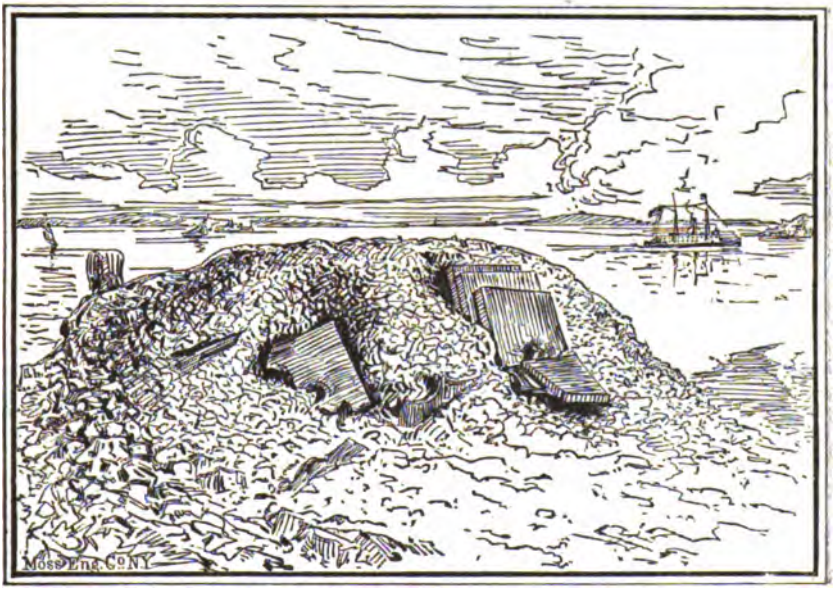
23. Fired at iron target, 15 inches thick, made up of five plates each, 3 inches thick. Shot penetrated the target and passed through 12 feet of frozen gravel. Point of shot intact. (See Mis. Doc. 170, part 9, H. R., Forty-fourth Congress, first session, page 96.)

Report of Captain Truxton, referring to shots fired on 28th November, 1873.

24. The projectile struck a little to the left and below the center of the target, passing through it at an angle and burying itself in the gravel of the butt, from which it was dug out very much distorted in shape, with a small piece chipped from the side of the apex and broken off at the neck. All the plates were driven well into the butt, very badly shattered, and two large pieces sent flying through the air a distance of 50 yards.

THE SMOOTH-BORE GUN.

THE TARGET AFTER FIRING—THE NUT ISLAND ORDNANCE EXPERIMENTS, PLATE 3.



THE EFFECT OF THE SECOND SHOT—THE SMOOTH-BORE GUN.

Two plates penetrated.
Three plates indented.

Projectile 460 lbs.
Powder charge 140 lbs.

THE TARGET AFTER FIRING.

Quotations from the general report of Capt. George Brown, naval inspector, on shots fired 28th November, 1873.

25. The spherical shot fired from the smooth-bore gun perforated two plates, badly indenting the third, and driving the plates well into the gravel of the butt. The shot was literally pulverized. (See Mis. Doc. 170, part 9, H. R., Forty-fourth Cong., first session, page 96.)

DÉBRIS OF TARGETS.

Report of Captain Truxton, referring to shots fired on 28th November, 1873.

23. * * * A spherical shot of the same weight and of chilled iron was then fired with same charge of powder from the smooth-bore gun at a target in all respects identical with the one already described. The shot penetrated the two first plates, badly indented the third, and drove them all well into the gravel of the butt. The projectile was literally pulverized. * * * * * * *

W. T. TRUXTON,
Captain U. S. N., Inspector of Ordnance.

Commodore E. T. NICHOLS, *Commandant.*

(See pages 130 to 132, Mis. Doc. 170, part 9, Fourty-fourth Congress, first session, H. R.)

THE PRESS.

[From the Boston Herald of November 29, 1873.]

27. Trial of the Wiard gun; a startling result; the most formidable shot ever fired; triumph of American ingenuity. * * * * * *

[From the Boston Daily Globe of November 29, 1873.]

28. HEAVY ORDNANCE TESTS.—Successful trial of rifle guns at Nut Island yesterday; a shot driven through fifteen inches of solid iron. * * * *

[From the Boston Post, November 29, 1873.]

29. HEAVY ORDNANCE EXPERIMENTS.—Fifteen-inch rifle guns for the Navy; a conical shot projected through fifteen inches of iron plating; iron-clads defenseless; a new era in warfare; how it will be utilized. * * * *

[From the Boston Daily Advertiser, November 29, 1873.]

30. ENGINES OF WAR.—The trial of heavy ordnance at Nut Island yesterday; successful experiments; terrible and irresistible weapons. * * * *

[From the Boston Journal, November 29, 1873.]

31. THE WIARD GUN.—Successful test of the heavy ordnance. In the presence of some fifty gentlemen a remarkably successful test of heavy ordnance was made at Nut Island, in Boston Harbor, yesterday afternoon, the two guns used, one smooth and the other rifled, being fifteen inches caliber and weighing 46,000 pounds. * *

[From the Boston Evening Transcript, November 29, 1873.]

32. The Wiard gun proved all and more than its inventor claimed for it in projecting force at the trial on Nut Island yesterday. * * * *

33. The Secretary of the Navy said:

34. Mr. Wiard succeeded in penetrating 15 inches of iron at a distance of 160 feet, with a projectile of his invention, fired from a 15-inch gun rifled on his plan. The official details of these experiments will be found in the reports of Commander Brown, United States Navy, and Captain Michaelis, United States Army, already communicated, and the official reports of Captain Truxton, the ordnance officer specially detailed to continue the experiments, and of Mr. Wiard to the Bureau of Ordnance, copies of which are hereto annexed, and marked respectively C and D. A statement and general description of these experiments and their results will also be found in the printed pages hereto annexed, numbered from 23 to 32, inclusive, and marked E. *They attracted great attention both here and abroad, as will be seen by the accompanying extracts from our own and foreign newspapers and periodicals, which are hereto annexed,* and marked F. *These reports show, as the result of the experiments, great success under particular circumstances, and the possibility of converting the large stock of unserviceable ordnance already on hand into most efficient and successful weapons of war at a very small expense.*

35. The inventor of the guns says:

36. By the firing on the 28th November, 1873, it was desired and intended to produce very startling results, by use of excessively heavy charges of the most effective powder for the penetration of armor plates.

37. At the time the Virginius excitement was at its height, our minister at Madrid had turned over the property of the legation to the Italian chargé d'affaires, and had demanded his passports (28th day of November, 1873, the very day their guns were fired).

38. A war with Spain was impending, the legation of the United States at Madrid was attacked by a mob, the press at home and abroad ridiculed our preparation for the contest, referring to the "utmost power of our cast-iron smooth-bore bombards" as insufficient to break through the weak armor of either "the Merrimac, the Atlanta, or the Tennessee," while the strength of the armor of the ships of war of Spain was magnified. A Spanish iron clad happened to be undergoing repairs in the dry-dock at Brooklyn navy-yard, with her armament and powder stored as if she was a prisoner of war, and her guns hostages on shore.

39. So great was the alarm at the thought of her liberation and the consequences to the city of New York, that a barge loaded with coal was secretly scuttled and sunk in front of the gates of the dock to prevent her getting out.

40. It was under these circumstances that the inventor of the Wiard gun inaugurated the Nut Island experiments.

41. Under the terms of his contract it was necessary to encounter the very difficult problem of producing an elongated conical shot of the same weight of a spherical one of the same diameter, so as to have all the conditions equal for the smooth-bore and the rifle gun, for all the experimental firing with this pair of guns. This was accomplished by forming a cavity in the rear or bore of the rifle shot, and the shot was consequently so short in its bearing in the grooves, when so prepared, that there was great danger of its turning over in the gun, and it was known that but a slight deviation of the direction of its axis would burst the gun, and thus ingloriously and unprofitably terminate the experiments. The inventor, who was alone responsible for the results, ac-

cepted the situation out of regard to the gravity of the occasion, and the result as shown by the official reports, and the "notices of the press," was full compensation for his risk and anxiety, showing a complete revolution of public opinion in relation to the fitness of cast iron as the material from which to make powerful rifle guns for the national defense.

42. The London Army and Navy Gazette, in the following, quoted from its columns, referred to the difficulty of producing a conical and elongated shot which should be of equal weight with a spherical one for the same caliber of gun:

43. While our English artillerymen, or rather the particular sect of them which ha its fetich at Woolwich, are shutting their eyes to whatever is going on in the rest of th world, content with repeating the liturgy of their faith in the "hardest-hitting, flat[e] test-trajectoried, longest-ranging, straightest-shooting gun in the world," the Americans, if we are to believe the deliberate statements contained in a paper of character, have produced a cast-iron gun—a material, according to Woolwich faith, utterly unfit for ordnance—which leaves far behind it the most advanced stage reached by our guns in destructive power. In an experiment at Nut Island the gun of which we speak, rifled on the system of a Mr. N. Wiard, drove a shot, 460 pounds, through a wrought-iron plate 15 inches in thickness. We are told that this gun, which weighs 23 tons was charged with 140 pounds of powder. The shot must have had something peculiar in its construction, because, although conical and elongated, it only weighed as much as a round shot fitting the same bore. * * *

44. The London Engineer, a technical journal of high character, published the following:

45. Some remarkable results have been obtained during the recent trials of naval ordnance, carried on under the supervision of Mr. Norman Wiard, at Nut Island, Boston Harbor. Mr. Wiard's improvement consists in rifling an ordinary smooth-bore gun with two grooves, having for a 15-inch cannon a twist of one turn in 50 feet, and cut in the sides of the bore so as not to cross the bottom. The object of this arrangement is primarily to allow the gun to be used as if it were a smooth-bore, and with ordinary spherical projectiles, which, were the upper and lower surfaces of the interior rifled, would in balloting destroy the grooves and strain and weaken the piece, while the firing would besides be greatly impaired in accuracy.

The trials above referred to have, however, proved an unusual gain of penetrating force, due to this system of rifling. Two ordinary smooth-bore guns, of 15-inch bore, were selected, one of which was grooved according to Mr. Wiard's plan, and provided with conical projectiles. The other was left in its normal condition, and ordinary round shot employed. The extremely large charge of 140 pounds of powder was used, and the projectiles weighed 460 pounds each. Two targets of wrought-iron plates, 15 inches in thickness, were erected side by side, 160 feet distant. The rifle was fired first, when its bolt went clear through the target, tearing off a huge fragment, and throwing the same a considerable distance, and then burying itself in a sand bank. The smooth-bore shot entered the target for 6½ inches, and there stuck.

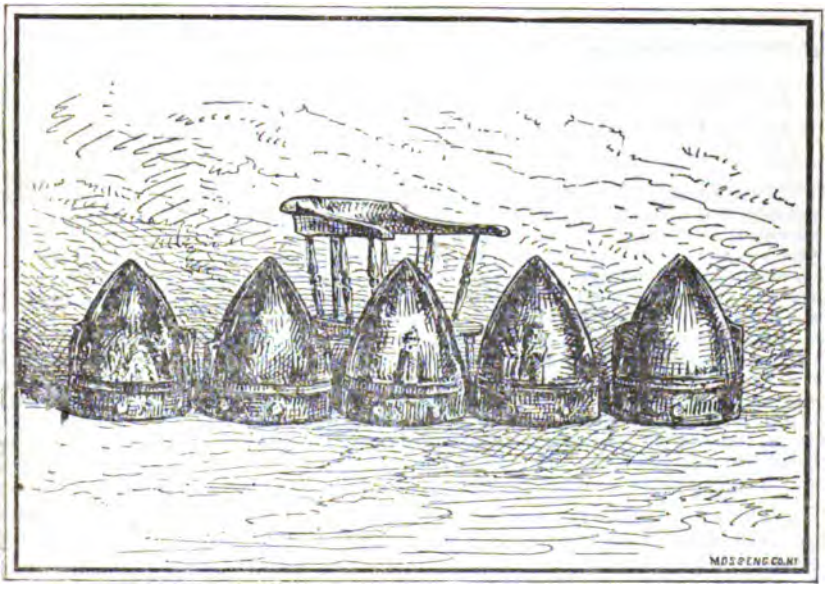
46. The experiments were of course merely designed to determine penetrative power, and hence were made at very short range, but we understand that further experiments are to be inaugurated for the purpose of estimating the comparative distance and rapidity with which the projectiles can be thrown from guns rifled after the Wiard pattern and smooth bores. It will be seen, however, that the results thus far obtained are better than those reached in the celebrated Tegel tests of the Krupp guns. * * *

47. The London Army and Navy Gazette referred to the Nut Island experiments again, as follows:

48. The experiments were made under the observation of Captain Truxton, captain of ordnance, of the Navy Department, and under the superivsion ofNorman Wiard, agent of the department and inventor of the rifling improvement. For the purposes of the experimental tests there were provided two guns of 23 tons each and of 15-inch caliber. One was the common smooth bore, and the other was rifled in accordance with Mr. Wiard's invention; but in other respects there was no difference whatever. One hundred and forty pounds of powder—the largest quantity ever used in a gun—was fired from each, and the projectiles were respectively of 460 pounds weight. The targets consisted of wrought-iron plates of 15 inches in thickness, and they were erected side by side, 150 feet distant. The rifled projectile fired from the Wiard gun was of conical shape, and the one fired from the common smooth-bore piece was necessarily round. The one first named went clear through the 15-inch plates, and out of sight into a sand bank in the rear. The demolition of the almost invulnerable

target was complete, and so great was the force with which it was struck that a fragment of 300 or 400 pounds was thrown clear across the island a distance of not less than a quarter of a mile. The projectile from the smooth-bore gun penetrated the target only about 6½ inches; and as the advantages were precisely equal, the superiority of the rifled arm was at once established by the experiment, and admitted by the government authorities of observation. * * *

49. The following tabulated statements are compiled from official reports:



RECOVERED PROJECTILES.

Shot on the right passed through the town of Hull.

50. The experiments were continued a few days later by firing the same pair of guns in competition, to determine their relative range.

Test for comparative ranges.

Date.	No. of shot.	Trial for comparative ranges at ten degrees elevation.				
		Charge.	Projectile.	Gun used.	Elevation.	Range.
1873.					°	*Yards.*
Dec. 7	1	50 pounds Oriental Mills, hexagonal.	450-pound spherical shot.	Smooth bore, 15-inch caliber.	10	3,035
7	2	.....do.....	450-pound Wiard conical shot.	Wiard rifle, 15-inch caliber.	10	3,570
7	3	.....do.....	450-pound spherical shot.	Smooth bore, 15-inch caliber.	15	3,950
7	4	.....do.....	450-pound Wiard conical shot.	Wiard rifle, 15-inch caliber.	15	4,390

51. From the above table it can be seen that the rifle gun showed marked superiority in range over its competitor of the same caliber, charge of powder, weight of projectile, &c.

52. The gain in initial velocity of the rifle gun over its competitor was, however, more remarkable and decisive as proving the superiority of the mode of rifling in connec-

tion with the mechanical fit projectiles than any other mode of determining the relative value, than even actually firing at iron targets. *The increased initial velocity is entirely due* to the mode of rifling, and the greater ease with which the shot is ejected from the gun. A greater penetration of iron might be, in part, attributed to the form of point and the diameter of the perforating body of the projectile.

Date.	Gun.	Charge.	Projectile.	Velocity.
				Feet.
Aug. 28	15-inch smooth bore	50 pounds Oriental Mills, hexagonal.	451-pound spherical shot.....	1,067
28	15-inch Wiard rifle, No. 1.	....do	457-pound Wiard conical shot	1,149
31	15-inch smooth bore	140 pounds Oriental Mills, hexagonal.	450-pound spherical shot.....	1,542
31	15-inch Wiard rifle, No. 1.	....do	453-pound Wiard conical shot	1,682

53. It will be noticed that in both cases the rifle shot was heavier than the shot from the smooth-bore gun, yet the heaviest had the highest velocity. The increase in power of the rifle over the smooth bore is in the ratio of (the square of the velocity multiplied by the weight) about as 5 is to 6 in the first pair of shots, and about as 4 is to 5 in the second pair. The ratio of increase of power between the 50-pound and 140-pound charges is about as 6 to 13, in both cases rifle and smooth bore, while the difference in the weight of the powder charges is in the ratio of 5 to 14.

54. Although a great many charges of 140 pounds of powder were fired from each gun, the official inspector's reports claim that neither gun was injured. (Page 97, H. Mis. Doc., 170., part 9, Forty-fourth Congress, first session.) Although the same reports of star-gauge measurements show enlargement at the seat of the shot in the smooth-bore gun of about .016 of an inch, while no enlargement was detected in the rifle gun. As to precision with the rifle, the inspector says: Of two shots out of seven aimed at the distant target, were "in perfect line with the bull's eye," and that the seven were "all good shots." (Page 97, *Ibid.*)

55. The proposal to the Secretary of the Navy to conduct the Nut Island experiments was presented in a letter dated New York, March 16, 1872, indorsed, "Combined rifle and smooth-bore guns—an improvement in heavy ordnance, by Norman Wiard," and was in effect a proposal to prove by practical experiments that smooth-bore guns of cast iron, such as were on hand in possession of the government, and utterly useless in their present condition, might be converted into powerful, enduring, and efficient "combined rifle and smooth bores" at very low cost, have the quality of powerful rifle guns imparted to them, with better endurance, and at the same time retain all their efficiency as smooth bores for shells and *ricochet* practice, so that they might be fired at will either with rifle projectiles or spherical ones, according to the requirements of service.

56. Without entering into a long disquisition on the subject, it is sufficient at this time to say that experienced officers, naval and military, earnestly desired to have such armament for reasons well understood and appreciated by themselves; and, after the proposal was presented to the Secretary of the Navy, it was shown to Admiral Porter, who promptly approved of the plan and immediately wrote the following letter expressing his views on the subject:

[Letter of Admiral Porter.]

OFFICE OF THE ADMIRAL,
Washington, D. C., April 5, 1872.

57. SIR: The attention of officers in the Navy is at present drawn to the plan of Mr. Norman Wiard for converting our heavy smooth bores into rifled guns, at an expense so moderate, for each gun, that the Navy can be placed in a much more efficient position than it has been for a long time past, and with a future prospect of at least being able to compete with the navies of some of the smaller powers.

58. Mr. Wiard tells me that he is in hopes that an appropriation of $40,000 will be made to carry on experiments with his 15-inch guns, and I sincerely trust that Congress

will grant the means necessary to carry out these most important experiments, which, if they succeed, as I am quite sanguine will be the case, will save millions to the country hereafter. Should the plan prove successful, we shall have what no other nation possesses, a combined rifle and smooth-bore gun.

59. Should the guns fail in the experiment, we should still derive important information from the trial, and shall not have expended one-tenth of the amount annually appropriated by the English and French Governments in trials of ordnance.

60. Hoping that you will give your hearty support to this important matter, I remain, very respectfully, yours,

DAVID R. PORTER,
Admiral.

Hon. JAMES A. GARFIELD,
Chairman Committee on Appropriations,
United States House of Representatives.

61. Official record can be cited to show that the Admiral, if he should be placed in the dilemma on the eve of a naval battle making it necessary for him to choose whether his ships should be armed with smooth bores or rifles exclusively, would have decided in favor of the smooth bores, while he would undoubtedly have been willing to accept a battery made up partly of smooth bores and partly of rifles, when, for such service as required one or the other, his armament would be reduced in proportion to the number of the opposite kind on board. Evidently, therefore, to his experienced mind, the "combined rifle and smooth-bore guns" were indeed a great desideratum.

62. The Nut Island experiments showed conclusively that the rifled guns were equally good smooth bores after the conversion, but as the two days' firing which demonstrated this *fact* are entirely left out of the official reports, the writer will not refer further to that part of his subject.

63. The letter addressed to the Secretary of the Navy, before referred to, dated March 16, 1872, ended with the following paragraphs, containing the whole of the proposal for the Nut Island experiments.

64. I have two smooth-bore guns of 15-inch caliber, of superior quality, cast hollow, and cooled from the interior, directly under the supervision of General Rodman. The guns are new, and were made by the South Boston Foundry. I will rifle one of these guns, furnish new wrought-iron carriages for them, two wrought-iron plates for targets, 4½ inches thick, 36 inches wide, and 144 inches long each,* all the necessary projectiles, both for the smooth-bore and the rifle-gun, and all the implements required for a comparative test of the efficiency and endurance of the two guns, having in view besides the determination of the question as to which gives—

65. 1st. Highest initial velocity to the shot of equal weight with equal charge of powder.

66. 2d. Longest range.

67. 3d. Best precision aimed at the bull's-eye of a target.

68. 4th. Which will penetrate a 4½-inch plate with the smallest charge of powder. And,

69. 5th. Which will have the greatest endurance fired with such charges as will give the highest velocity to the shot from the smooth-bore gun.

70. I will furnish all the ordnance stores above enumerated and all the powder necessary for all the trials enumerated, together with the guns described, and conduct the test under the patronage of the Navy Department and the observation of such naval officers as you may direct to attend and record the result, for the sum of $40,000, to be paid to me in advance, upon my giving security satisfactory to you for the faithful fulfillment of the conditions of a contract which shall embrace and express all these terms and conditions.

I have the honor to subscribe myself your obedient servant,

NORMAN WIARD.

Hon. GEO. M. ROBESON,
Secretary of the Navy, Washington, D. C.

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*The condition relating to the targets was afterwards changed by mutual agreement, and targets 15 inches thick were furnished.

71. The Secretary wrote the following letter in response to the above proposal:

FORTY-SECOND CONGRESS, SECOND SESSION.

Letter from the Secretary of the Navy.

APRIL 10, 1872—Referred to the Committee on Appropriations and ordered to be printed.

NAVY DEPARTMENT,
Washington, D. C., April 4, 1872.

72. SIR: I have the honor to recommend that an amendment be inserted in the bill making appropriations for the naval service for the next fiscal year, appropriating $40,000 to enable the department to purchase two special, large, trial guns, and to conduct a series of experiments for the purpose of determining practically whether the present smooth-bore guns of the Navy can be increased in efficiency and strength by rifling and by the use of a new projectile, with a view of obtaining more reliable endurance, longer range, better precision, and a greater power of penetrating iron plating.

73. A plan for this purpose has been laid before the department which is claimed to possess such merit that it is deemed desirable to submit it to a full and complete comparative test.

74. The sum named is, by the terms of the proposal, to cover the entire cost of the two new 15-inch guns necessary—one of them to be rifled—together with all the projectiles, powder, iron plates for targets, carriages, and appliances required for the entire test.

75. The proposed expenditure is much below the usual cost attending similar experiments, and may result in enabling us to improve and utilize such of our present stock of guns as we may wish, at a trifling outlay per gun.

76. The importance of obtaining for the Navy large rifled guns of great power and certain endurance is believed to fully warrant the department in asking for the appropriation herein recommended.

I am, sir, very respectfully, your obedient servant,

GEO. M. ROBESON,
Secretary of the Navy.

Hon. JAMES A. GARFIELD,
Chairman of the Committee on Appropriations, House of Representatives.

77. And Congress promptly passed the naval appropriation, in which was included the following:

[GENERAL NATURE.—No. 79.]

AN ACT making appropriations for the naval service for the year ending June thirty, eighteen hundred and seventy-three, and for other purposes.

78. *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That the following sums be, and they are hereby, appropriated, to be paid out of any money in the Treasury not otherwise appropriated, for the naval service of the Government for the year ending June thirtieth, eighteen hundred and seventy-three, and for other purposes.

* * * * * * *

79. To enable the Secretary of the Navy to carry on his experiments towards converting heavy smooth-bore guns into rifled guns, with a view to obtain a combination gun possessing the qualities of both smooth-bore and rifle, forty thousand dollars.

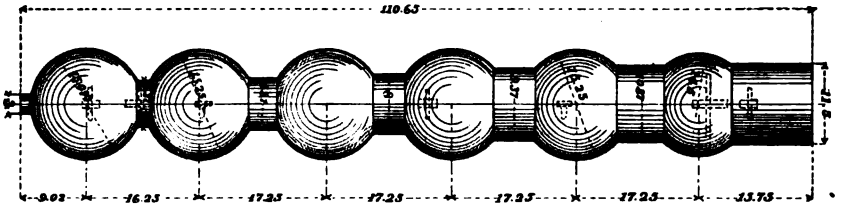
Approved May 23, 1872.

80. In order to avoid just cause of cavil as to the fairness of the competitive firing between the two guns, the powder for a pair of charges was in each case emptied from the barrels upon a wooden platform and carefully mixed with a wooden shovel. Then the cartridge-bags were carefully filled by alternate shovelfuls as fairly as possible to equal weights, and when the guns came to be fired, the inventor was stationed at the guns and the official inspector at the magazine. The inspector did not know which gun of the pair was to be first loaded, nor did the inventor,

who directed the loading, know which of the two cartridges would be sent forward first.

81. Captain Truxton, referring to this in his report, says: "I witnessed the weighing of the powder and filling the cartridge-bags."

82. The very best quality of shot procurable were provided for the smooth-bore gun. They were cast in clusters in a perpendicular position, with a "sinking head," after an approved method, illustrated and described in the report of the Chief of Ordnance for 1880. The following cut is taken from the report, showing the form of the casting:



83. When so cast, the balls are turned in a special lathe to exact dimensions, and the finished shot has superior density, with a smooth surface, less hard than the skin upon a projectile cast in the ordinary manner. They are also far more costly.

84. On the other hand, the condition of the contract and the importance of securing a competitive trial on exactly equal terms between the guns, as nearly alike as was possible, created great embarrassment on account of the shortness of the bearing of the rifle projectile in the grooves of the gun. The shot was liable to turn over in the gun, and if such an accident should occur during the firing, with the heavy charges used to test the relative endurance of the guns, the gun would surely burst and thereby terminate the experiments ingloriously. In point of fact, one or both of the flanges of every one of the distorted conical shot used in the rifle-gun that was recovered was found to be more or less broken, an example of which is shown by the following cut (see also cuton page 66):

RECOVERED PROJECTILES SHOWING BURNISHED MARK FROM UPSETTING.

85. So that up to the time the experiments under the appropriation approved March 16, 1872, terminated, the smooth-bore gun had been served with the very best projectile procurable, and the competing rifle with the worst one compatible with the theory of the invention undergoing test.

86. In the later contracts, under which the experiments were continued (the relative power, initial velocity, range, precision, and endurance of the competing guns having been determined under such equal conditions as have been described), the embarrassing condition of equal weight between such dissimilar projectiles was omitted; and when the new projectile, called the "lenticular" or "mitten shot," was perfected, no apprehension was felt and no anomalous result was obtained.

87. The Army inspector present said of this new projectile:

88. I regard the lenticular or "mitten" shot as the best instrument yet handled by artillerists for the penetration of armor plates. Its true flight and low trajectory were hard to explain. * * * The 15-inch gun has done some really admirable work. With a moderate charge and a heavy projectile it pierced the Prince's head target at a distance of 1,650 yards—a greater range against iron, so far as I can ascertain, than has ever before been attempted. * * * We have now what appears to me to be an admirable exponent of the centering system.—From the general report of Capt. O. E. Michaelis, U. S. A.

89. The naval inspector, Capt. George Brown, said of it in his general report:

90. The mitten shot has certainly shown great powers of penetration when fired at either iron targets, through hard gravel, or into the hard, distant bank.

91. Of the mitten shot fired from the 15-inch and 11-inch guns, none broke up in the guns, and of the many recovered none had failed to work properly.

92. The Secretary of the Navy, in his response to the inquiry from the Naval Committee of the House of Representatives, said:

93. Besides a great amount of new and valuable information upon the subject-matter experimented upon, certain specific results were obtained, which illustrated the power of our cheap cast-iron guns rifled on the Wiard plan, and the wonderful penetrating effect of the projectile devised and manufactured for the experiments by him, notably the penetration of 15 inches of iron and a considerable depth of frozen gravel by a conical shot from a 15-inch gun, rifled on the Wiard plan, on the 25th of November, 1873.

94. The penetration by the Wiard mitten shot, fired on the 2d of October, 1875, of which the record is as follows:

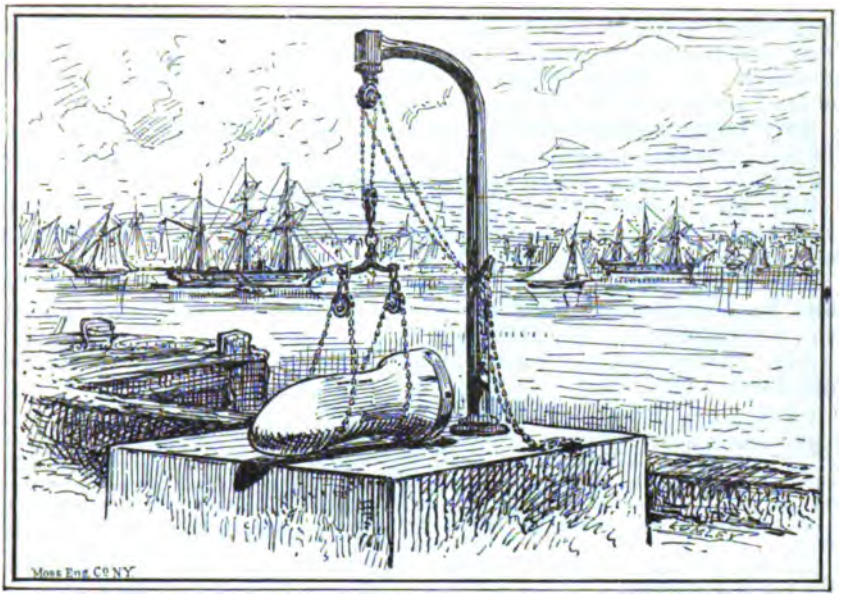
95. "Target, five 3-inch plates, backed by sand, and three 3-inch plates laid horizontally; shot went through all and 13 feet 11 inches of gravel."

96. The penetration of four 3-inch plates (12 inches) of iron by the Wiard mitten shot from a 15-inch Wiard rifle, at a distance of 1,650 yards (near a mile), October 23, 1875.

97. The penetration of 38 feet 4 inches of sand and hard gravel by a Wiard mitten shot fired from a Parrott gun, rifled on the Wiard plan.

98. The penetration of 16 inches of iron on the 22d of November, 1875, by a Wiard mitten shot from a 9-inch Parrott gun, rifled on the Wiard plan.

99. These results are certainly very remarkable.



THE WIARD "LENTICULAR" OR "MITTEN SHOT."

100. The official reports show—

101. First. On the 28th November, 1873, the smooth-bore gun, of the pair mounted on Nut Island at that date, was fired at an iron target 15 inches thick, composed of 5 plates, each 3 inches thick, banded together at the top and bottom, and backed by frozen gravel. The target weighed 15,000 pounds; the charge of powder 140 pounds. The projectile was a superior spherical one and weighed 450 pounds.

102. The shot penetrated two of the five plates [6 inches of iron] and lodged "literally pulverized" against the third plate, which it badly indented, and that was all.

103. Second. On the same day the rifle gun of the same caliber, weight, and dimensions, mounted by its side on a like carriage, was fired at a target in all respects identical with the one already described. The projectile weighed also 450 pounds, the same as its competitor. The charge of powder was, as with the competing gun, 140 pounds of the same kind. The shot fairly went through the target (15 inches of iron) and through 12 feet of frozen sand and gravel in addition.

104. Third. The smooth-bore gun of the same pair was then fired at the sand and gravel butt with a *spherical projectile* of 450 pounds, and 140 *pounds of powder, no iron target intervening.* The shot penetrated 16 feet, only four feet more than the rifle shot had penetrated *after passing through* 15 *inches of iron.*

105. Fourth. The smooth-bore gun was then rifled identically the same as its competitor, and on the 9th of October, 1875, was fired at the same butt, no iron target intervening, with 50 *pounds of powder*, and a *"mitten shot"* of 525 pounds weight, and it penetrated 32 feet 8 inches, more than double the penetration with a charge of powder reduced nearly to one-third.

106. Fifth. On the 2d October, 1875, the same gun was fired at an iron target 15 inches thick, composed of 5 plates, each 3 inches thick, of the

aggregate weight of 15,000 pounds, banded together at the top and bottom, and backed by sand and gravel, and three 3-inch plates laid horizontally. *The charge of powder was 70 pounds.* The projectile was a chilled *mitten shot*, of 530 pounds weight.

107. The shot passed through the 15 inches of solid iron and penetrated 14 feet of gravel in addition. (Capt. O. E. Michaelis' report says 13 feet 11 inches; Captain Brown's report, 14 feet.)

108. The following illustrations drawn from photographs taken on the spot and at the time of the events exhibit, first, the target before firing, second, third, and fourth, the target after firing.

109. Copies of the original photographs were forwarded to the War and Navy Departments, to the Ordnance Bureau of the Navy, and to the Army Ordnance Department.

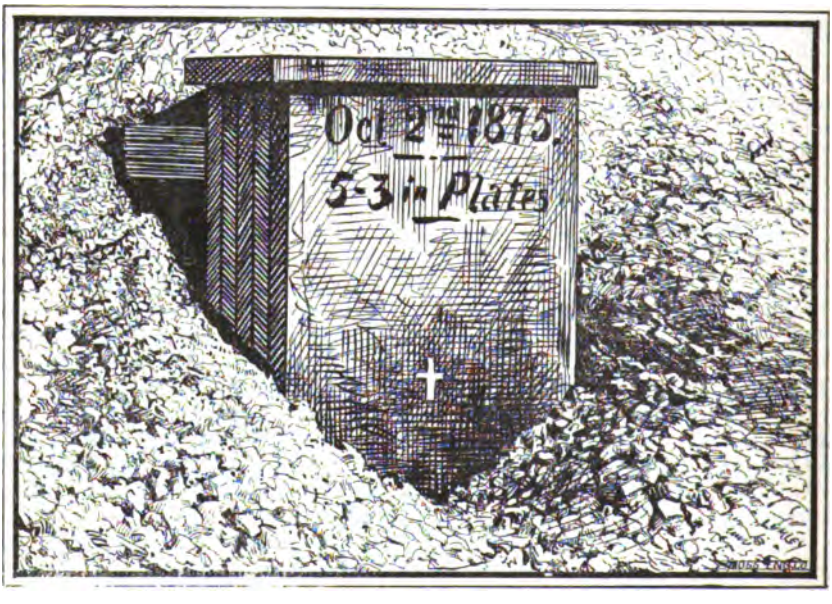
110. The Secretary of the Navy described this target in the following words:

111. Besides a great amount of new and valuable information upon the subject-matter experimented upon, certain specific results were obtained, which illustrated the power of our cheap cast-iron guns, rifled on the Wiard plan, and the wonderful penetrating effect of the projectile devised and manufactured for the experiments by him—notably the penetration of 15 inches of iron and a considerable depth of frozen gravel by a conical shot from a 15-inch gun, rifled on the Wiard plan, on the 25th of November, 1873.

112. The penetration of the Wiard mitten shot, fired on the *2d October*, 1875, of which the record is as follows:

113. Target, *five 3-inch plates, backed by sand, and then 3-inch plates laid horizontally.* Shot went through all and 13 *feet* 11 *inches of gravel.*

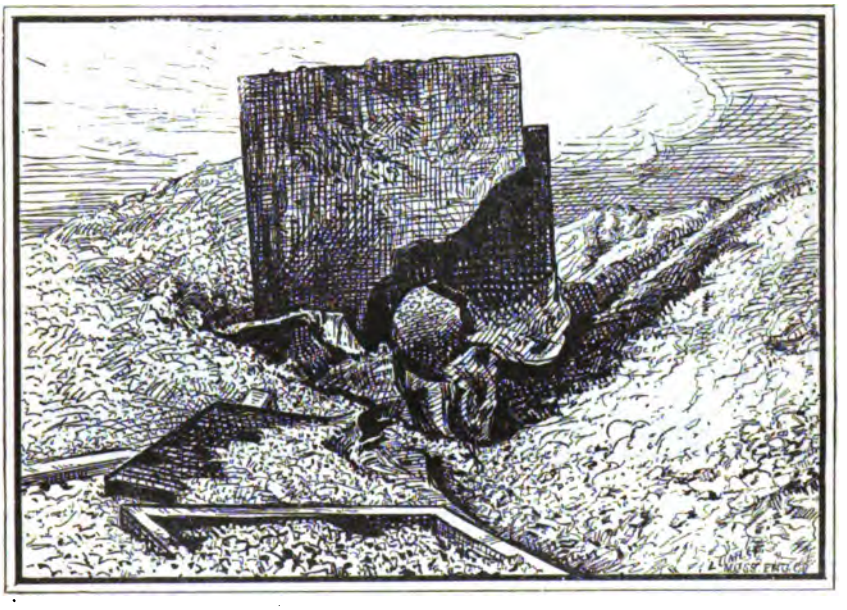
THE TARGET.



114. Capt. George Brown in his report says:

115. On October 2d the same gun was fired a 70-pound charge and a solid "mitten" chilled shot of 530 pounds, and aimed at a 15-inch iron target made up of five 3-inch plates, and held together at the top and bottom by wrought-iron endless bands, backed by iron plates and gravel, and distant 184 feet 3 inches from the gun.

FRONT VIEW OF TARGET AFTER FIRING.



116. The above picture, taken five minutes after the shot was fired, shows the perforation of the iron, and the path of the shot through the sand and gravel behind the target.

THE EFFECT OF THE SHOT AS DESCRIBED IN THE OFFICIAL REPORTS.

[From Capt. George Brown's report.]

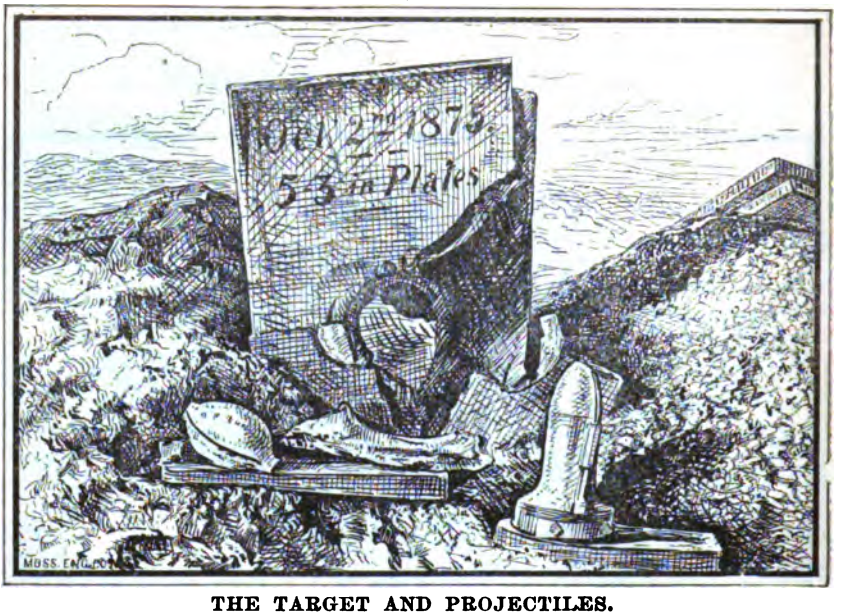
117. Recoil was 17 feet 10 inches. Velocity, 1,324 feet per second. The shot struck fair, went through the target, and penetrated 14 feet into the hard gravel.

118. Capt. O. E. Michaelis, U. S. A., said in his official report:

119. The shot struck the center of the target with the effect graphically shown in Plates IV, V, and VI. The projectile was found 13 feet 11 inches in gravel. The point of the shot was found to be intact. The body was somewhat upset, and superficial cracks were visible below point at distorted part. (See Plate VI.) The sabot-end (windage-band) was forced off entirely, though its entire vis viva seems to have been imparted to the perforating "mitten" body.

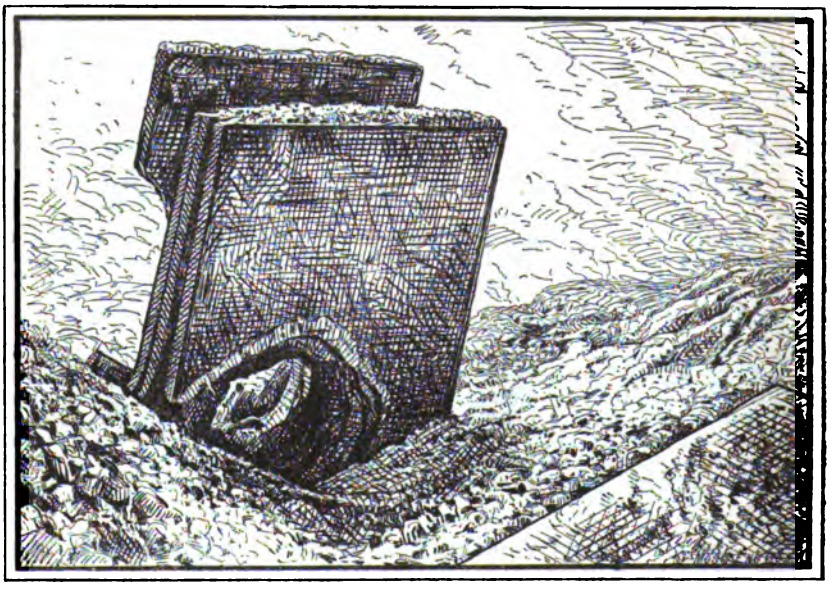
120. The front plate assembled showed the peculiar form of the shot and the marks of the lugs. (Plates VI and VII.)

121. And the Secretary of the Navy, in his reponse to inquiry by the House Committee on Naval Affairs: "Shot went through all and 13 feet 11 inches of gravel."



THE TARGET AND PROJECTILES.

122. This view shows the front plate, one-half of which had fallen forward; after it was restored to its position; on the left the shot which passed through the target; on the right a mitten shot before firing.



REAR VIEW OF TARGET.

123. The English 81-ton gun required 320 pounds of powder to attain a penetration of 45 feet into a sand and gravel butt similar to the one erected on Nut Island.

124. On the 24th of November, 1875, an 11-inch Wiard-Parrott, combined rifle and smooth-bore gun—converted from a Parrott 300-pounder—

was fired at the "butt" with a 60-pound charge of powder and a mitten shot of 308 pounds weight. Referring to the result, Capt. O. E. Michaelis, U. S. A., inspector, present on the part of the War Department, says:

November 24, 1875.

125. Gun, 11″ Wiard Parrott.
126. Charge 60 pounds, O. M. Hex.
127. Shot, 308 pounds, lenticular (fired once before).
128. Recoil, 4 feet 1 inch.
129. Aimed at butt; shot struck near bulkhead, penetrating about 40 feet in gravel, and was removed uninjured.

130. Referring to the same shot, Capt. George Brown says in his report:

131. On November 24 this gun was fired at the butt, the conditions being the same as given above. The shot was recovered uninjured, having penetrated 40 feet into hard gravel.

132. Thus it is proved that the Nut Island experiments, conducted at the joint cost of the Government and the inventor (total cost $269,141, of which the Government paid $152,000, and the inventor $117,141), for the purpose of testing improvements in ordnance—much needed—resulted in establishing wonderful gain of power by simple methods of extreme cheapness and readiness of preparation, viz: From the penetration of 6 inches of iron with a charge of 140 pounds of powder, to the penetration of 15 inches of iron and 14 feet of hard earth (the same identical gun being used in both events) with a powder charge of only 70 pounds of powder.

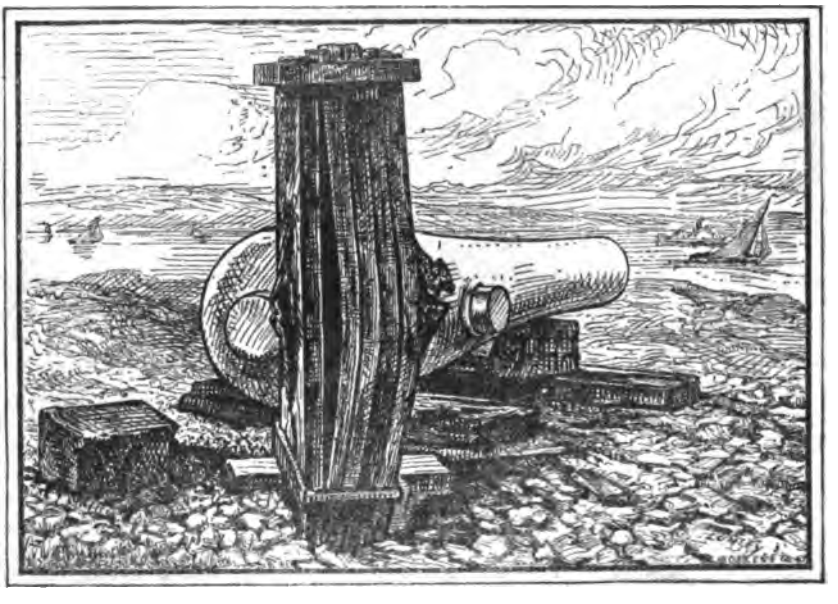
133. A like gain of power is shown by the penetration in hard gravel.

134. The smooth-bore gun, with a charge of 140 pounds of powder, penetrated 16 feet of hard gravel.

135. The same gun, when converted on the Wiard plan, penetrated 32 feet 8 inches in hard gravel, with a powder charge of only 50 pounds.

136. It is to be noticed that all the results hereinbefore referred to are consistent, and seem to preclude the idea that any of them were accidental.

137. They do not, however, stand alone. Other shots were fired and many other targets were penetrated even more astonishingly than is sh own inthe examples already described.



TARGET 24TH NOV.

138. On the 24th of November, 1875, the 11-inch Wiard-Parrott gun before referred to, was fired at an iron target 15 inches thick, in all respects like the 15-inch targets before described.

139. The charge of powder was 60 pounds, and a mitten shot weighing 308 pounds was used. The effect on the target is graphically shown by the photograph.

140. Under a contract dated 28th February, 1874, the Navy Department put the experimenter in possession of four 8-inch Parrott rifle guns, called by the maker 200-pounders, by the Ordnance Bureau 150-pounders.

141. The record—as far as it is public—shows that 22 guns of this kind and caliber had burst prematurely in battle with extremely small charges of powder (16 pounds). They were essentially condemned guns.

142. The Secretary of the Navy, in referring to the experiments under this contract, says:

143. Entertaining these views, the department suggested that the experiments should be confined to experiments directed towards the immediate utilization of the great mass of rifled guns now on hand, but unserviceable or inefficient for the purpose of modern warfare.

144. In entering upon the work under this contract, from a misunderstanding of the directions to the workmen at the foundry, these guns were rifled with a pitch altogether too slow, and, therefore, the experiments, so far as attempted at long range, were not satisfactory. But it is obvious that such an error can be easily corrected in the next guns which may have to be converted.

FRONT VIEW.—TARGET 22D NOVEMBER.

145. The object of imparting the rotating motion to a projectile by rifling is to secure a flight point first, or so that the longest axis of the projectile will coincide with the direction of its flight. This object was not secured for long ranges and even for short ranges; at the near target it can be seen, from the shot having passed diagonally through the target, that at the moment of striking it was in the act of turning a somersault. This caused to make a perforation through 16 inches of iron, while the target was in reality only 12 inches thick.

146. The Parrott 8-inch gun converted to a 9-inch Wiard-Parrott was fired on the 22d November, 1875, with 40 pounds of powder, and a "mitten shot" of 204 pounds weight.

147. This was the first occasion of a rifle projectile of moderate caliber perforating an iron target of a thickness greater than the caliber of the gun in inches.

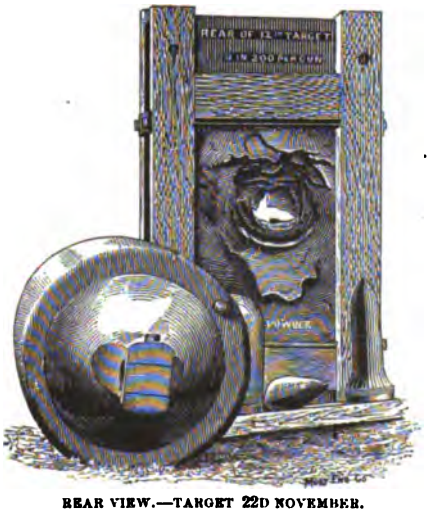
148. In this case the thickness of iron perforated was nearly twice the caliber of the gun.

149. No such remarkable result can be referred to in the whole range of the records of ordnance experiments.

150. The English 9-inch gun, it is well known, is only capable of forcing its shot through 9 inches of iron (the thickness of the Hercules target), and that only with 60 pounds of powder.

151. Capt. O. E. Michaelis in his report says:

152. Fired at 12-inch iron target. Shot penetrated, taking diagonal downward course. Point absolutely uninjured. Found in gravel three feet behind target. The iron of this target was very tough.



REAR VIEW.—TARGET 22D NOVEMBER.

153. Capt. George Brown says:

154. Fired at iron target 12 inches thick. * * * Shot struck fair, taking a downward direction, which caused it to pass through about 16 inches of iron. Shot was found 3 feet in rear of target.

155. On the 19th of November, 1875, the 9-inch gun was fired at the sand butt for penetration. *The charge of powder was* 30 *pounds;* the project ile a "mitten shot" of 203½ pounds weight.

156. The result is best described by quoting the official reports. Capt. George Brown's report says:

157. The velocity was 1,332 feet per second. The shot was recovered, having made the remarkable penetration of 38 feet 4 inches in hard gravel, being found 3 feet below the original soil.

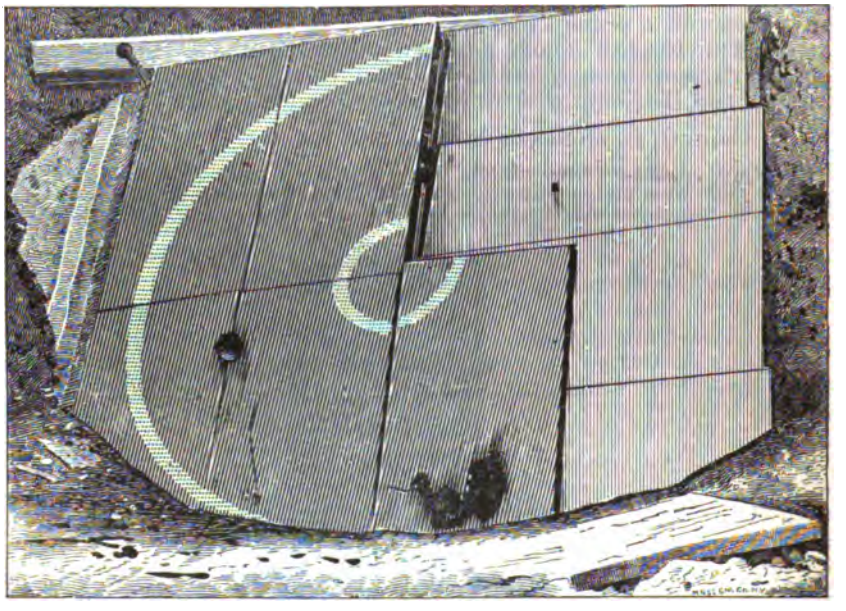
158. [NOTE BY N. W.—It should be known that the original soil of Nut Island, one foot below the surface, is an extremely hard conglomerate of clay and water-worn pebbles and bowlders. It was found that excavations were made into it with great difficulty.]

159. Capt. O. E. Michaelis, in his official report, says:

160. Shot found 38 feet 4 inches in ground 3 feet below the original soil.

THE DISTANT TARGET.

161. October 23, 1875, the 15-inch combined rifle and smooth-bore Wiard gun (being one of the original pair of 15-inch guns fired at iron fired on the 28th of November, 1873, with 140 pounds of powder) was fired with a powder charge of 70 pounds at the great Prince's Head target, distant 1,650 yards (nearly a mile) from the gun.



THE GREAT PRINCESS HEAD TARGET.

Perforation of great target on Prince's Head, by mitten shot from the Wiard 15-inch gun, Oct. 23d. The photograph was taken after temporarily readjusting the right hand half of the target, which had been taken down to photograph rear plates. Target on Prince's Head, 15 feet square, 12 inches thick, 1,650 yards from the gun; composed of 32 plates, 7 feet 6 inches x 3 feet 9 inches and 3 inches thick each; total weight, 96,000 lbs. Gun 15-inch caliber; cast-iron Rodman, converted to "Wiard's Combined Rifle and Smooth-bore." Shot Wiard improved mitten from chilled cast-iron, weight 531 lbs. Powder charge 70 lbs. Oriental hexigonal. The target was perforated entirely through. Initial velocity of shot 1,307 feet per second.

162. This target was 15 feet square and 12 inches thick; its total weight was 96,000 pounds, and it was composed of 32 iron plates each 7 feet 6 inches long, 3 feet 9 inches wide; each plate weighed 3,000 pounds.

163. The plates were of remarkable uniformity of thickness and their edges were planed to practical nicety of dimensions, so that when assembled in the mass to form the target their surfaces were brought together in excellent compact contact of solid iron.

164. In erecting the target, a good "bond," or system of "breaking joints," was chosen, so that the vibrations of concussion from any point of impact would be pretty fairly distributed throughout its whole mass.

165. The top of the target was firmly clamped by heavy oak timbers bolted together from front to rear.

166. Thus constructed and erected, the target had a peculiar quality of solidity without injurious tensions which would assist the force of the projectile in breaking through. At the same time it was elastic, and

thereby the *time* of the shot in passing through was extended, and to some extent expended in causing vibrations throughout the whole mass of its 96,000 pounds of iron. Thus the shot was obliged to expend more of its *work* upon the target than was necessary to merely penetrating it.

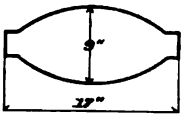
167. After the firing it was observed that the rear plates immediately behind the point of impact were driven back into the hard conglomerate of clay and bowlders about two feet, and the point of the shot when recovered was found to have penetrated about three feet into the hard earth backing, although its base was surrounded by the fragments of the rear plates which it had perforated and shattered.

168. On account of the elasticity before referred to, fully 40,000 pounds of front iron plates were thrown forward by the rebounding of the plates behind, and were scattered on the beach in front of the target, projected from ten to twenty feet. And every plate of the target was found to be more or less dislodged from its original position. The photograph was taken after the target was partly readjusted for the purpose.

169. Capt. O. E. Michaelis's report describes the event as follows:

October 23, 1875.

170. Gun, 15-inch Wiard rifle.
171. Charge, 70 pounds O. M. Hex.
172. Shot, 531 pounds, lenticular (original model).
173. Velocity, 1,307 feet.
174. Elevation, 3°.
175. Recoil, 4 feet.
176. Fired at the Prince's Head, 12″ target; range, 1,650 yards.
177. The small recoil was due to a radical change in the arrangement of the snubbing-ropes.
178. The winch heads were inverted, the larger bases being outside, and the standing springs at the free ends were replaced by a simple wooden friction compressor *carried by the carriage.*
179. Plate VIII shows the Prince's Head target.
180. The shot struck exactly the point aimed at, about 18 inches from bottom of right-hand center-plate, 28 inches to right of left edge, and 6 feet below center line of target, penetrating the four plates, though sticking in the fourth plate.
181. The sabot part came off; the sound was musically steady, note clear, uniform, and sustained. The shot struck fairly point foremost. The perforation in front plate showed the form of the shot, and was about of this shape:



182. The corresponding dimensions of shot were 15¼″ and 9′. The fourth plate was completely shattered.

183. The target was described in the report of Captain Brown as follows:

184. On September 16 the firing at the iron target on Prince's Head was commenced.
185. This target was distant 1,650 yards from the gun, and was 12 inches thick, with a face 15 feet square. It was composed of 4 layers of 3-inch plates, each 7 feet 6 inches long and 3 feet 9 inches wide. For a backing a smooth-faced excavation was made in the very hard bank. The plates were placed one edge on the other, breaking joints, and being inclined at an angle of 27 degrees from the perpendicular; were supported by their own weight and clamped together at the top by heavy wooden beams.

186. And he refers to the results of the firing in another part of his report as follows:

187. On October 23 this gun was fired at the iron target on Prince's Head (heretofore described), distant 1,650 yards. The charge was 70 pounds. The shot was a solid

"Mitten" chilled shot of 531 pounds. Elevation, 3 degrees. Recoil, 4 feet. Velocity, 1,307 feet per second.

188. The shot struck the target direct, 28 inches to the right of the center line, and 18 inches above the lower edge of the target. The base of the shot broke off in three pieces on striking the target.

189. The forward part of the shot was found wedged in the rear plate, having perforated the four plates, aggregating 12 inches in thickness. All the plates through which the shot passed were broken.

190. Several remarkable shots have been omitted from the official record.

191. The inventor's diary September 16, 1874, notes the following:

192. The first shot was fired from the Wiard rifle; charge, 140 pounds of powder; weight of shot (first pattern conical), 452 pounds. Time, 12.23 p. m. Velocity, 1,645 feet. Elevation of chassis, 7½°. Elevation of gun, 2°. Gun trained to 30 feet to the left of target on Prince's Head (1,650 yards distant). Time of flight, 3 seconds to first graze.

193. To the surprise of all persons present, with the low elevation of 2°, this shot passed over Prince's Head Island, raising a slight cloud of dust. Mr. Wiard crossed over, and found the shot, as it passed, had made a perceptible path in the grass 55 feet in length. He returned to Nut Island, and two additional shots were fired with same conditions, except for the first of the two. The elevation of the gun was reduced to 1⅝°. This shot struck low, a little beyond high-water mark, on Prince's Head Island. The next shot with same conditions, except elevation of gun, was increased 1 1/16°. The shot struck higher up, and with a ricochet passed over the island, grazing the boom of the derrick on the top of the bank, as it passed to the right. Time of flight of both the latter shots, 3¼ seconds.

194. These shots showed the flattest trajectory which can be found for so low elevations. Upon returning to Boston in the evening, it was learned, greatly to the regret of the experimenter, that the first shot fired on that day had passed *en ricochet* through the wharf of Hull, and after a number of grazes in the principal street of that town (see cut, *ante*, page 66), greatly endangering life, and causing alarm to the inhabitants; had continued its course through and beyond, along the outside sea-beach, and was picked up at the government wharf at Point Allerton, 4 miles away from the gun. It was said to have skipped along the water between Prince's Head and Hull with six grazes. It passed through one of the piles of the wharf cutting it in two, and that it rebounded from the sand between Hull and Point Allerton twelve times; thus making the most remarkable range of 4 miles, with two degrees of elevation to the gun, and meeting obstruction by grazing the water, the wharf, and the sand at every rebound.

195. For years previous to the inauguration of the Nut Island experiments the favorite theory of official ordnance authorities, to account for the bursting of cannon of large caliber had been to attribute enormous, erratic, and unexpected pressures to the gases of gunpowder.

196. The fact was overlooked that no higher velocity to the shot was attained when the Rodman pressure instrument indicated 160,000 pounds pressure to the square inch on the interior of the chamber of the gun with a 50-pound charge of the common mammoth powder, gave no higher velocity to the shot of 450 weight than was given by the same number of pounds of powder to the charge, to a projectile of the same weight fired from the same day when the indicated pressures were no higher than 60,000 pounds.

197. It was a very convenient theory, but not logical; and whenever

a gun burst, even if the pressures were not taken, it was assumed that it was only an indication of a high pressure, and one of the anomalous results that could not be avoided.

198. The writer drew the attention of the Secretary of the Navy to the necessity of experiments to determine whether with the same gun a like charge of powder by weight and kind, and a like projectile of the same weight, the pressures would not be uniform; and an invention was exhibited to him which would measure the instant pressures of powder in a gun the same as a steam gauge shows the pressure of steam in a boiler, an instrument which would eliminate all the projectile force, of which velocity and time of action were elements, and show the highest instant pressure only, not the momentum of the flowing gases.

199. The Secretary authorized the experiment, and the "dynamometer" was made and tested. The following is the report of its trial. After describing the instrument, the report says:

200. To use this instrument it is first placed in a frame fitted to hold it firmly on the weighing machine, and turning on a spindle that brings the different holes successively under the pressure piston. The copper specimens are put in, the indenting tools, then pistons, and finally the sleeves and glands are screwed into place. Any desired pressures are then applied to the nine different indenting tools, and the instrument taken apart again. The cuts made in the copper disks are marked by dividers, replaced, and the instrument put together again the same as before, screwing the gland down hand-taut upon the piston, except that a copper gas-check is put in the hole of the gland over the piston, and a little tallow placed over it. The shot is now ready for firing. Upon four separate occasions it was found that the cut made by applying a pressure of 27,000 pounds per square inch upon the piston-head was not enlarged by firing; though frequently the cuts of pressures greater than that were enlarged and always those of less pressures.

I am, sir, your obedient servant,

H. W. LYON,
Lieutenant, United States Navy.

Capt. WILLIAM N. JEFFERS, U. S. N.,
Chief of Bureau of Ordnance.

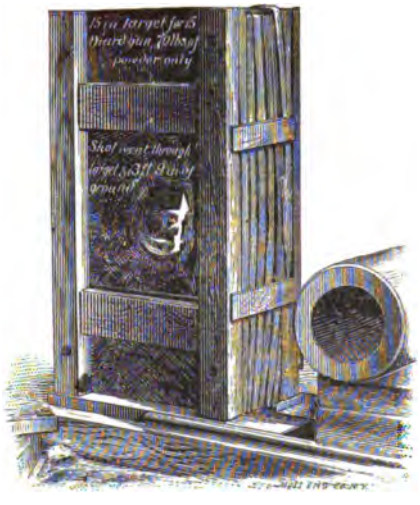
Nut Island experiments, for pressure.

201. [Gun, 15-inch smooth-bore.—Elevation of gun, level.—Charge, 50 pounds Oriental Mammoth July, 1872.—D., 1.733.—Elevation of slide, 3°.—Projectile, Wiard "Manometer;" weight, 598 pounds.—Average recoil, 12 feet 3 inches.—Gun aimed at butt; distance, 50 yards.—Average penetration, 12 feet.]

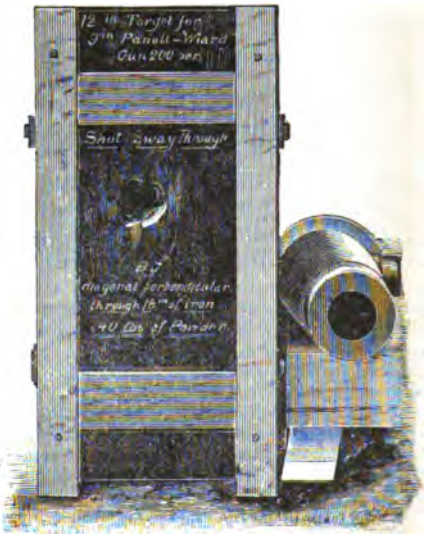
Pressures applied to indenting tools by weighing machine.	Initial velocity.	Remarks.
7,000 to 15,000, inclusive	1051.5	All initial cuts enlarged after firing.
14,000 to 22,000	1025.0	All enlarged; in some cases cuts of least pressure enlarged most.
20,000 to 28,000	1009.5	Initial cut of 27,000 pounds not enlarged. A little fine sand had passed up from fore end of shot into two chambers.
22,000 to 30,000	988.0	Noticed small particles of copper ground off cuts; knife-edges showing side-motion of indenting tools; cut of 27,000 not enlarged.
26,000 to 34,000	1012.0	Initial cut of 27,000 pounds not enlarged, though most of the cuts of over 27,000 were.
26,000 to 34,000	1031.0	Arrangement of dowels to prevent side-motion of indenting tools. Cuts more uniform after firing.
25,000, 27,000, 28,000, 30,000, 34,000, 38,000, 42,000, 46,000, 50,000.	1013.0	Cuts of 27,000 and upward not enlarged, except that of 42,000, which was lengthened on one end.

202. A modification of the manometer was proposed by the inventor, which was to adjust the instrument permanently in the bottom of the bore of the gun, as it was believed that all the overpressures above 27,000 pounds came from the projectile striking sideways in the gravel of the butt. The suggestion was not, however, acted on until the experiments terminated. Enough was learned, however, from the experiment to show

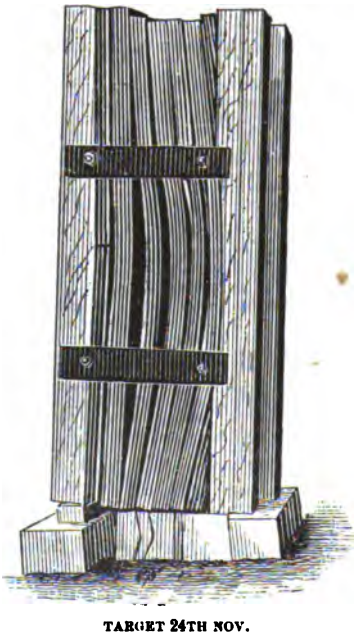
that the Rodman instrument was entirely unreliable, inasmuch as the lowest pressure indicated for the same kind of powder was 42,000 pounds to the square inch, while some of the indications with the same powder were as high as 85,000 pounds.



TARGET OCT. 2D.



TARGET 22D NOV.



TARGET 24TH NOV.

203. During the fall of 1875, as the Nut Island experiments were approaching their termination, a number of the targets, such as had exhibited the remarkable power of the guns experimented with on Nut Island, were assembled and bolted together in frames of wood preparatory to transportation.

204. It was proposed to exhibit them at the Centennial, and afterwards transport them to Washington, where it was arranged that they should be set up as trophies of the most successful and wonderful series of practical experiments in ordnance ever essayed; but, during the absence of the inventor in Japan, adverse influences hindered the carrying out of the project.

205. If these targets and the guns had been publicly exhibited at Washington, as contemplated, it is probable that Congress would not have appropriated the hundreds of thousands of dollars since expended for the procurement of officially patented guns, which have since burst or have failed in proof—guns made on the most senseless plans, often tested previously, and which have failed as often as tried, during the past one hundred and fifty years.

206. With the targets, it was intended to exhibit two of the guns which had been fired and had "performed really admirable work."

207. The one the muzzle of which is seen with the target of October 2, is the identical gun which fired the first shots on Nut Island in 1872; while it remained a smooth-bore it was fired a number of rounds with 140 pounds of powder, a few with 100 pounds, and many of 70 pounds, 50 pounds, and 55 pounds. Afterwards, when it was converted to a combined rifle and smooth-bore, one of its shots pierced the Prince's Head target with a moderate charge, "striking exactly the point aimed at," and at a range of 1,650 yards. It penetrated 42 feet of gravel with 70 pounds of powder, and if it has not been destroyed since the Nut Island experiments terminated, it is to-day the most efficient and powerful gun of its weight and cost in the world.

208. The Wiard Parrott 9-inch gun, another one it was intended to exhibit at the Centennial and afterwards remove to Washington, is also the most powerful and efficient gun of its weight and caliber in the world.

209. Since the completion of the Nut Island experiments, the inventor, aided by the extraordinary practical experience gained—probably no private citizen ever before had such an opportunity—has continued his studies and experiments. The result has been that the best of his creations developed while the Nut Island experiments continued are now entirely superseded by his later inventions, which as far excel his previous results as his "converted gun" and the "mitten shot" excelled the old "smooth-bore gun" and "spherical shot." Yet, the mitten shot, with the system of rifling to which it was adapted, still retains its superiority over all others produced and publicly tested by any one else, or anywhere in the world, so far as is known, with equal charge of powder, weight, and cost of gun and projectile, and caliber of gun.

210. The CHAIRMAN. You said a while ago that the United States have so many guns?

211. Mr. WIARD. They have 1,650 guns of 10 and 15 inch caliber on hand.

212. The CHAIRMAN. Of what kind?

213. Mr. WIARD. Smooth-bores—ten and fifteen inch guns. Many of them have not been fired.

214. The CHAIRMAN. Have these guns been used?

215. Mr. WIARD. They have never been fired in battle; some of them have been proved by three rounds.

216. The CHAIRMAN. Where are these guns?

217. Mr. WIARD. In the fortifications and at the arsenals.

218. The CHAIRMAN. Are they all smooth-bore?

219. Mr. WIARD. All smooth-bore, muzzle-loading guns.

220. The CHAIRMAN. Costing about how much apiece?

221. Mr. WIARD. The 15-inch guns cost $6,500 apiece for the bare gun, and then there are carriages, implements, projectiles, &c., for them on hand. The 10-inch guns cost $1,650 apiece.

TARGET 24TH OCTOBER.

222. The CHAIRMAN. Cast-iron guns?

223. Mr. WIARD. They are cast-iron guns.

224. The CHAIRMAN. These guns, you say, can be converted by a system of rifling?

225. Mr. WIARD. If I was about to have my life depend on the success of a 10 or 15 inch gun fired with such charges as I fire, and I had to stand right by, I should prefer a cast-iron gun to a gun of any other material; and in a few days I will give you such reasons for that as will satisfy you that I am right. I have been twenty years considering the subject.

226. The CHAIRMAN. How many of these guns did you manufacture for the government?

227. Mr. WIARD. About 10 or 12.

228. The CHAIRMAN. Where are those guns that you rifled?

229. Mr. WIARD. According to the contract, all that was left there after the experiments belonged to the government; but the instant the experiments were completed, and without any notice to me at all, they were advertised for sale at auction, and I heard on the morning of the day they were to be sold that a party was going down to the island to sell them. I went down with them and hastily made arrangements by which I bought the targets that I had prepared to send to the Centennial Exhibition, and two of the guns, and I left those on the island. The balance was taken away.

230. The CHAIRMAN. Were the others sold?

231. Mr. WIARD. Everything was sold.

232. The CHAIRMAN. Who bought them?

233. Mr. WIARD. Junk dealers bought the old iron. The government wanted to get them out of the way.

234. The CHAIRMAN. You say the government sold them?

235. Mr. WIARD. The government sold them.

236. The CHAIRMAN. To whom?

237. Mr. WIARD. To the highest bidder; I do not remember whom.

238. The CHAIRMAN. Sold for old iron?

239. Mr. WIARD. They were all sold in fact and at old iron prices, and I bought part of them.

240. The CHAIRMAN. Was it the Ordnance Department of the Navy or of the Army which did that?

241. Mr. WIARD. The Ordnance Department of the Navy. They were very bitter against me from the beginning of the experiment to the end.

242. The CHAIRMAN. Who was the chief ordnance officer?

243. Mr. WIARD. Capt. William N. Jeffers.

244. The CHAIRMAN. Where is he now?

245. Mr. WIARD. He has skipped away to Europe. He was afraid I was going to have him prosecuted before the grand jury here for malfeasance in office.

246. The CHAIRMAN. His going away to Europe would not prevent his being prosecuted.

247. Mr. WIARD. He wanted to get away, perhaps, so that he might have leisure to consider what to do.

248. The CHAIRMAN. The reports from which you have read were made by men who were present and saw the experiments?

249. Mr. WIARD. Yes, sir; they are on record.

250. The CHAIRMAN. They reported in favor of your system?

251. Mr. WIARD. They reported the facts.

252. The CHAIRMAN. And then the guns were sold for old iron?

253. Mr. WIARD. Yes, sir; in spite of my protest, and that at the worst time in winter, when the snow was very deep, when very few people would go to bid. It was with the greatest difficulty that I could secure from the sale the instrument that I made to determine the pressure of powder, and after awhile it was concluded to take that back to the navy-yard.

254. The CHAIRMAN. Who is connected with the Ordnance Department of the Navy now that knows anything about this?

255. Mr. WIARD. I suppose everybody in the Ordnance Office does.

256. The CHAIRMAN. I want the name of somebody.

257. Mr. WIARD. You will get the reports from Capt. George Brown, of the Navy. Captain Jeffers had the reports submitted to him, with photographs showing all these things as I have stated them. They were sent to the Secretary of the Navy, the Secretary of War, and to the Army Ordnance Department, with the reports and photographs showing the guns before and after firing, the projectiles, and the targets before and after firing. There never was a series of experiments conducted with greater care. Every step of the progress was recorded in such a way by stenography and photography, many witnesses being present, that no one could doubt.

258. The CHAIRMAN. Where is the officer who was present at the experiment?

259. Mr. WIARD. I do not know. I have never seen him since that time. While I was in Japan he gave some very untruthful and disgraceful testimony before a committee of Congress. I was informed of it while I was there, and I wrote a letter which was published in the Boston Herald, of which I have a copy, charging him with doing what no gentleman would do; but he never replied, as far as I know. I have never

seen him since nor heard from him. It was the determination of the Department to sacrifice me and prevent my guns from being adopted at any cost whatever.

260. In one part of my contract I agreed with the Secretary of the Navy to fire one pair of guns of each caliber rapidly for thirty rounds to show that it was the heating of the interior of the gun that caused the gun to burst rather than the pressure of the powder. That could be shown better by rapid firing, and I considered that it would demonstrate, if the guns did not burst, that they could endure an ordinary battle without bursting, as no rifled gun has ever yet endured the test of battle firing. I got the guns and my part of projectiles ready, the guns mounted, and in the——

261. The CHAIRMAN. Find out where that man is. I would like to have him before this committee.

262. Mr. WIARD. I have no power to bring him.

263. The CHAIRMAN. I ask you to find out where he is.

264. Mr. WIARD. An order communicated to him through the Secretary of the Navy would reach him. He may be on sea service; I do not know.

265. I should like to continue until I explain about this rapid firing. It was inserted in the contract that the Navy Department should furnish the projectiles for the gun that I was to compete with; I was to furnish powder for all the guns, and projectiles for my own. I prepared the powder and projectiles for rapid firing, and when I was ready sent to the navy-yard nine miles away for projectiles. I did not go myself, but sent for them, as I was told they were ready. They sent back five. Of course I could not fire 30 rounds consecutively with five projectiles. I then went to the navy-yard; did not fire that day, and tried again. They told me I could not have any more than five until I had fired the five. I found also that the Chief of Ordnance had given directions to the inspector that he was to have a swab with a certain compound of grease and plumbago made, and that was to be inserted in the gun before it was loaded and after, and every time the gun was fired it was to be swabbed out and examined, all these conditions to prevent the rapid firing of the gun. At Fort Fisher 46 men were killed or wounded with the same guns exactly; because they were fired rapidly. I wanted to show what was the cause of the bursting of the guns. I had spent nearly a million of dollars in learning what was the cause, and I wanted to have everybody know it, but I was prevented.

266. Mr. HUBBELL. Did the guns you fired burst?

267. Mr. WIARD. No gun with my projectile ever burst. There were three guns burst on the island, but always with another projectile than my improved shot. While I was in Japan the Chief of Ordnance himself wrote a letter, which was entirely untrue, which was published everywhere in Japan, which he gave to an English gunmaker, who took it with him and caused it to be published in Japan and China at the time I was negotiating with the Japanese Government for a large quantity of ordnance. In that letter he stated that all of the guns fired by Mr. Wiard on Nut Island had burst. The experiments were his own, and, it was not considered worth while to make any report. It was signed "William N. Jeffers, Chief of the Bureau of Ordnance, Navy Department." Captain Jeffers did not make any report, because he feared to have a comparison of the results of my experiments with those being made by the Navy Department. At the time I fired the first shot on Nut Island, on the 28th of November, 1873, our full Navy was down at Key West, watching the Spanish; and just as quick as I fired this shot Captain Jeffers issued

an order directing the use of 100 pounds of powder in the 15-inch guns, when before that the charge had only been 35 pounds.

268. The CHAIRMAN. How many of these guns did you fire at Nut Island?

269. Mr. WIARD. About twelve.

270. The CHAIRMAN. And burst three?

271. Mr. WIARD. Yes; but no gun burst with any of my improved projectiles.

272. The CHAIRMAN. Why did you fire them with unimproved projectiles?

273. Mr. WIARD. I was firing them in competition to determine the advantage of the different improvements in the art of making guns, and, as previously stated by the terms of my first contract, the weight of the rifle shot had to agree with the spherical one to make the conditions equal for comparison.

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274. Mr. NORMAN WIARD submitted the following:

WASHINGTON, *January* 5, 1883.

THE NATIONAL DEFENSE AS DEPENDENT ON THE SOLUTION OF THE ORDNANCE PROBLEM.

1883.

It is most meet we arm us—gainst the foe,
For peace itself; should not, so dull a kingdom—
[Though war, nor no known quarrel were in question,]
But that defences, musters, preparations;
Should be maintained, assembled, and collected;
As were a war in expectation.

King Henry V, Act II, Scene IV.

In the modern quick and decisive settlement of differences by the arbitrament of arms there is not time for preparation after the declaration of war; and a nation may sink beneath the powerful blows of a well-armed adversary in less time than it takes to manufacture a single gun.—*Report of the Chief of Ordnance.*

A LETTER ADDRESSED TO THE SENATE SELECT COMMITTEE ON ORDNANCE BY NORMAN WIARD.

Senators of the Select Committee on Ordnance:

275. I believe it is understood by you that notwithstanding the millions of dollars appropriated and expended during the past thirty years by our ordnance authorities for the procurement of armament for the coast defense, fortifications, and naval vessels, there is not at this time a single cannon of commensurate power and undoubted endurance in the possession of the government, stored in its arsenals, ready in its forts, or mounted on its ships of war, either smooth-bore or rifled.

276. It is believed that a single modern iron-clad ship-of-war could enter any, even the richest, of our commercial ports, destroy public and private property, or put cities under contribution, and return leisurely afterwards with the plunder.

277. I am aware that many profess to believe that at the occurrence of invasion reliance may be placed on torpedoes, entanglements, and channel obstructions, if all other means fail; but the best authorities agree that by means of these we can hope for no more than to hold the invader longer under fire of cannon at the entrances. If we have no powerful guns mounted, then that would give but little advantage. Once in; all the shots fired for the defense that miss the enemy may work their destructive powers in the warehouses and homes of the friends of the gunners who aim them. It would be better perhaps to let the enemy have his own way in that event and at that place.

278. As to planted torpedoes for defense. It is known that devices

are prepared and brought with invading ships and fleets by which they may be "pulled up like cabbages."

279. The wires laid for fixed electric torpedoes may be ruptured or disarranged by dragging chains or grapnels across them, and advanced skirmishers in submarine armor may march on the bottom, covered and protected by the water, ahead of the invading fleet or ship, and clear the way by cutting wires or prematurely bursting the mines. I saw a foot-race across Boston harbor between two men in sub-marine armor, running on the bottom and towing floats on the surface; both contestants made good time. Mr. Townsend, a well-known citizen of Boston, was one of the contestants.

280. Protection against traveling torpedoes is now provided with every ship of war, or may be improvised from materials on board, and the principle of fighting fire with fire [in respect to these], torpedoes against torpedoes, is now well understood, and full preparation for it is found in the outfit of modern ships-of-war of every nation, and even means to prevent the entrance of water into the ships through the wound inflicted on her bottom by torpedoes are available, and are also provided in ships liable to such assaults. Further, the chances that the unprotected invading ships will not hit the torpedo or the torpedo the ship are altogether in favor of offense—as witness Admiral Farragut's entrance into Mobile Bay—and it must be remembered that floating batteries, war-ships with cannon, and swift torpedo-boats could not co-operate to prevent the entrance to our harbors of a hostile ship or fleet if the bottom of the channel was bristling with torpedoes, as liable to destroy a friend as a foe; and the use of channels so obstructed for commercial purposes must be abandoned until peace is restored.

281. It is practically conceded by all military nations having a coast line to defend that the surest, cheapest, most imperishable, and always ready means for harbor defense is to be found in cannon of larger caliber, long range, and sufficient power, so mounted, and in sufficient numbers, side by side, that simultaneous volley-firing may be resorted to in all cases where a single shot, striking a vital part of the iron sides of the enemy, would not be sufficient to prevent the hostile ship from running her course past the shore battery.

282. Guns on shore have the advantage of guns afloat for simultaneous volley-firing or salvos. The recoil of twenty broadside guns delivering twenty shots of an aggregate weight of no more than 14,000 pounds in one salvo would be sufficient to turn the ship from which they are fired upside down. If her *metacenter* and center of weight were near to each other, she would roll over and over many times in response to such an impulse.

283. In a fort the effect would not be at all injurious, while the effect of the impact caused by the simultaneous striking of twenty shots, each weighing 700 pounds, with a velocity of 1,680 feet per second, against the side of an iron-clad, would be the utter destruction of the ship.

284. Taken in connection with improvements of obvious practical utility in the projectile, a change from the lenticular to the triangular form. Of rifling with three grooves instead of two, and very important improvements in the form of grain and adjustments of densities in powder, by which greatly reduced strain upon the gun results, together with greatly increased velocity and power to the projectile, with an improved form of cutting point, [improvements made since 1875], which together render rapid firing with large guns possible, the Nut Island experiments indicate the most practical method for utilizing the guns on hand making each one equal to five ordinary guns for the complete arming of the coast defense fortifications, quickly prepared and very cheap.

285. At this time no nation is in possession of cannon or the knowledge of how to make them of sufficient power to penetrate the iron sides of the thickest armor now found possible within the carrying power of ships-of-war, cannon which are at the same time capable of delivering a rapid, consecutive succession of projectiles without bursting the guns.

286. As the thickness of the armor of ships-of-war has been increased the guns have been also enormously increased in weight, until 100-ton bombards have been procured; and on account of this increase in weight the number has been necessarily reduced, until in the very best examples of a modern ship-of-war we find no more than four guns, often only two, form the whole armament. Thus it may happen that the whole offensive power of a great ship-of-war, which has cost from three to five millions of dollars, might be rendered inoperative in one engagement, lasting no more than half an hour. I ask attention to the following:

287. The admiralty have had their attention called to the fact that the whole offensive powers of the Glatton are dependent upon the life of two of these guns; and as naval warfare demands continuous and quick firing, it is proposed to try whether one of the Glatton guns will endure a whole day's practice, firing 100 rounds at a target, with several degrees of elevation. This may set at rest an important point, which has never been settled, viz: Whether ships armed with 25-ton guns would not be disarmed by their own projectiles in the midst of an ordinary naval action.—(Naval and Military Gazette, May 11, 1872.)

And whether guns under condsideration are of small or large caliber is of importance.

288. It has been a primary principle [said Admiral Dahlgren] in making cannon that the larger the caliber the greater the liability—I might almost say certainty—of its bursting.

289. The practical experience of all gun-makers goes to show that there is no uncertainty of endurance in small guns—only large ones burst; and that the strongest material does not make the strongest large gun, while the stronger it is the better for small guns.

290. Theoretically, a rifled gun of small caliber, made with an interior steel tube, upon which a series of wide, homogeneous steel bands are shrunk and screwed on, one over the other, to make up a thickness of wall around the bore equal in aggregate thickness to the diameter of the bore or the caliber of the gun, provide transverse strength, ought to be and is more than four times as strong for actual service within its sphere as a cast-iron gun cast in one homogeneous mass and cooled slowly from the exterior of the same dimensions, if the cast iron having but one-third the tensile strength of the steel of which its competitor is made. But for such slow firing as prevails on the firing ground (say one round every five minutes consecutively), if served even with moderate charges of quick, burning powder and expanding projectiles, the steel gun will surely burst, if of [8-inch caliber or larger], before it has reached its tenth consecutive round, while the cheap cast-iron rifle may endure 1,000 rounds with such powder, at the same rate of rapidity of repetition of fire; while at a some still slower rate, either gun might endure thousands of rounds.

291. The Joint Committee on Ordnance of the Fortieth Congress had this seeming anomaly under consideration, and in its report said:

[Fortieth Congress, third session Senate, Rep. Com. No. 266, page 3.]

292. Each system of guns introduced in our service has been subjected in proof to tests supposed to demonstrate beyond question its ability to perform the work required of it, but each has failed when submitted to the real test of service.

In the operations upon Morris Island 22 large guns was the greatest number

mounted at one time, yet 50 in all burst during the siege, as is shown by the evidence of General Gillmore.

In the attack on Fort Fisher all the Parrott guns in the fleet burst, according to the report of Admiral Porter. By the bursting of five of these guns at the first bombardment 45 persons were killed and wounded, while only 11 were killed or wounded by the projectiles from the enemy's guns during the attack.

The battle of Fort Fisher was the only occasion during the war when rifled guns of large caliber were fired rapidly and continuously for a great number of rounds.

293. The failure to discover the weakness of these guns before putting them in the field or on board ship for actual service, must be attributed to a defect in the system of proof employed.

294. These systems appear to have been comparatively valueless, and to have proven little or nothing respecting the ability of the gun to perform the work expected of it in battle.

295. The committee cannot learn that any method of proof has been practiced in the Army or Navy which subjects guns to the tests they must endure when first brought into actual combat, namely, rapid and continuous firing, with intervals only sufficient for loading.

296. Excessive charges have been used and a great number of rounds fired, but no attempt has been made to copy upon the proving ground the conditions existing in battle.

297. In the new conditions developed by the rapid and long-continued firing in battle, not present during the slow and careful firing when in process of proof, it would seem must be found the cause of the frequent rupture of the guns.

298. The most important new condition present during rapid fire would seem to be the communication of a greater amount of heat to the bore of the gun, having a tendency, by its expansive force, to aid the powder in effecting a rupture.

299. If the gun be fired rapidly, so as to allow little time for the bore to cool between each discharge, it is believed that the heat communicated would exert a powerful expanding force; while if there should be long intervals between the shots, even if the charges were excessive, sufficient heat to burst the gun might not be communicated to the interior.

300. In reports of ordnance officers, the effect of unequal cooling in inaugurating unfavorable tensions in a gun cast solid and cooled wholly from the outside is treated at length, and it is shown that fissures and ruptures have resulted from the contraction towards the outside as the gun cooled, and it is stated that three-fifths of the strength of the gun is expended in this manner, leaving only two-fifths to restrain the pressure of the powder.

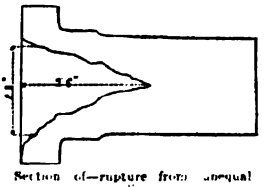
301. The hollow mode of casting of the Rodman system, and the band of wrought iron applied to the Parrott gun, were intended to utilize this force of contraction, by assisting the strength of the iron to restrain the pressure of the powder. It was afterwards noticed that several of the Rodman guns cast hollow, and cooled from the interior, burst in the foundry from the excess of this force of contraction exerted in the opposite direction from that before referred to.

302. If the force with which metals contract when cooled is shown to be so potent as to breakthe gun from the inside when cooled from the outside, and from the outside when cooled from the interior, it can be seen that if the gun be in a state of tension, which has the tendency to compress the metal of the interior and extend the exterior, the heat afterwards communicated to the surface of the bore by the burning powder, or by friction of the moving charge, would assist the pressure of the powder to break the gun, especially if the gun should be fired a number of rounds in quick succession.

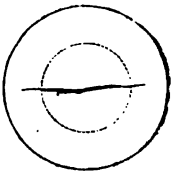
303. This additional force being considered, it may be possible to determine why guns made of the strongest material are more liable to burst than those made of weaker iron, and why the accidents occur most frequently during battle, when the gun is fired more rapidly than at the time of proof, when it is usually fired slowly.

304. Forces known to be sufficient to actually break large masses of iron, spontaneously, as it were, should not be overlooked while treating so intricate a subject as this of heavy guns.

305. Mr. Holley refers to the rupture of a large mass of wrought iron prepared by Mr. Mallett, in England, as attributable to "the force of contraction from the center toward the exterior as the mass cooled."



Section of rupture from unequal cooling.



Ruptured in cooling.

Such ruptures of large steamboat shafts are frequently noticed, and contraction of this kind may explain the fissures in large wrought-iron guns which have been noticed, as well as the soft and easily compressed nature of the iron in the interior of the mass of all classes of large guns.

306. The above part of the report of the committee it is believed was founded upon the testimony of the writer and upon citations from authorities, &c., laid before the committee during its inquiry, as well as upon the results of practical experiments conducted by the writer previous to the examinations of the committee and during the time the inquiry continued.

307. All these efforts were devoted toward the elucidation of the effects of unequal heating or cooling of guns, and the consequent unequal expansion or contraction of the metals of which guns are made.

308. The following extracts from a well-known authority were republished in the report of the Senate committee, No. 266, Fortieth Congress, third session, and are a most excellent confirmation of the conclusions arrived at by the writer after a long-continued and costly series of practical experiments, conducted for the sole purpose of establishing the cause of the uncertainty of endurance of guns of large caliber, espe. cially the cause of those accidents which occur to rifled guns of large caliber when fired rapidly, as in battle.

EFFECT OF HEAT ON GUNS.

[Extract from Mallett on Artillery.]

309. * * * Applying Professor Hodgkinson's experimental results as to the extensibility of cast iron under strain to this reasoning, and taking the coefficient of expansion by heat for cast and wrought iron as the same for low temperatures (strictly as 1000893, 1000894 for temperatures under 212°), we have the extension for cast iron for the square inch of section equal about $\frac{1}{3000}$ of its length for each ton of load up to seven or eight tons, at which its elasticity becomes permanently impaired; that is to say, when it begins to lose its form. An equal change of length is due to 8° Fahrenheit in temperature.

310. Let us now assume a 64-pound shot rammed home at 2,000° Fahrenheit, which is under a white heat, and that it remains 50 seconds in the gun while the latter is being run out and fired; that in this interval the shot transmits $\frac{1}{10}$ of its heat to an equal mass of the cold gun, and that the whole of this is operative in expanding a cylindric ring of a determinate thickness around the ball, then we have

$$F=\frac{200}{8}=25 \text{ tons}$$

as the mean compressive strain per square inch upon this interior ring. But as the ultimate cohesion of cast iron does not exceed about eight tons to the square inch, the actual effect upon the strength of the gun is the same as if about three inches of its thickness were removed, or that an inch in thickness of its interior metal were removed, and a total strain of 17 tons were at the same time visited upon the remaining section of its thickness. At such a conjuncture, with such a steady strain already on its metal, the gun is fired and an additional impulsive strain, equal to the work done in giving to the shot its initial velocity, is suddenly brought upon its material.

311. This, even with the regulation reduced charge for hot shot of three-fourths the service charge for cold shot, is seldom less than 2¼ tons on the square inch of section, producing from the impulsive nature of the force an extension equal to that of a passive strain of 5 tons. The wonder, then, is rather that any gun stands than that many should burst.

312. A train of effects quite analogous to those described are brought into operation in *very quick firing*, whether with hot or cold shot, when the interior of the gun, continually receiving fresh accessions of heat from the rapidly succeeding flashes of powder, is not given time to transmit it by conduction through its metal to the exterior. The limit of the heat that could be conceived communicated from one discharge to the gun would be the whole of that generated by the ignition of the charge. Assuming the formula for gunpowder to be $K\,O, NO_5 + S + C_3$, its atomic weight will be 135, and one part by weight will include 0.1333 of carbon. Now, Andrews (Reports Brit. Assoc., 1849) found that one part of carbon evolves as much heat in burning as will raise an equal weight of water 7900° Cent. Hence, neglecting the sulphur, as not oxidized in combustion, the heat generated by the firing of any charge of powder is sufficient to raise the temperature of an equal weight of water $7900° \times 0.1333 = 1053°$ Cent. $= 1895°.4$

Fahrenheit, or to boil about nine times its own weight of water, or to heat about nineteen times (18.945 strictly) its weight 100° Fahrenheit.

313. SECTION 95. In this case (that of heating by quick firing) the interior expansion is not almost limited, as in the former, to a ring in the immediate neighborhood of the shot, but extends to the whole length of the chase or bore, so that the whole gun becomes lengthened by the "end on" strain of its expanded interior.

314. And in giving testimony before the Subcommittee on Appropriations of the Senate having charge of the fortification bill, January 7, 1881, the writer said:

315. Now, in testing guns there is a quality of test that has never been applied in this country or in Europe.

316. A large proportion of all the force that has a tendency to burst a gun comes from the unequal heating of the gun that results from friction of the projectile as it passes out of the bore in perhaps the two-hundredth part of a second.

317. All the guns that have been heretofore made by our Ordnance Department, or nearly all of them, have been adapted to and supplied with a kind of projectile called "expanding projectiles" (patented by Capt. J. G. Butler, of the Ordnance Corps).

318. These projectiles are made with a body of cast iron or steel, and they have a soft-metal sabot about the base, and they are inserted into the gun just in front of the cartridge, a position called "the seat of the shot."

319. Upon the ignition of the charge they receive the impact of the tremendous force, which has a tendency to drive the sabot forward, expanding it to fill the grooves of the gun; at the same time jamming it forward and squeezing it between the rigid body of the projectile and thesurface of the bore.

320. This has the effect to enlarge or stretch the bore of the gun at the seat of the shot, as all the tables of enlargement which accompany the reports of inspectors of guns show, and thus the bore of the gun becomes a tapered tube, of largest diameter at the position from which the shot starts as it is being ejected from the gun by the tremendous forec of the exploding charge of powder, and the bore of the gun, being smaller toward the muzzle, the almost incompressible projectile has to be squeezed through the tapered tube in a fraction of a second of time.

321. The result of the friction, in addition to the retardation of the projectile, detracting from its power, is the evolution of a large amount of heat, which, expanding the interior of the gun in advance of the heating of its exterior, is the principal cause of its bursting.

322. Prof. F. A. P. Barnard, of Columbia College, in a letter he was kind enough to write me many years ago in relation to this subject, said: "There is no strength whatever which can possibly be given to a gun which the immense force arising from unequal expansion by heat will not be sufficient to overcome."

323. It is evident that if the friction of one projectile passing out of the gun raises the temperature of the interior, and a sufficient interval should elapse before the next shot it would return to its normal temperature again.

324. If two shots were fired in quick succession more heat would be communicated and retained in the interior of the gun than if only one was fired; and if a large number of rounds, 30 or 40, should be fired in quick succession, with the expanding projectiles, heat enough might be evolved to weld the shot to the metal of the gun or melt it.

325. Not so, however, with the Wiard shot, called "mechanical fit" projectiles.

326. These do not change their form in the gun or expand in the grooves, but pass out with the same diameter and form they have when inserted, as easily and freely, because the friction is no greater.

327. Therefore, even if the bore should be enlarged in diameter at the seat of the shot, and tapered thereby, the effect would be to only make the shot fit more loosely in the gun at that part, and slide out along the rifle grooves more easily, without any tendency whatever to unequally heat or burst the gun.

328. This is the principal feature of my system of rifling, and of the projectiles adapted to it; and knowing that expanding projectiles have a greater tendency to burst the gun under rapid firing, which my projectiles do not, *I am anxious to see the two systems tested by firing the guns in competition, with equal rapidity, for at least thirty rounds.*

329. *If that test proves to be one that either or both the guns cannot stand without bursting, it being the real test of battle, is it better to find it out now, before* $140,000,000 *are expended for a useless armament of the fortifications*, or to wait until the gun is surrounded by patriotic soldiers or citizens in actual battle array, defending their homes against an invading foe?

330. The expanding projectile and the system of rifling adopted for the Crispin patent guns are the most unmechanical devices that ever were conceived by any person in the world for a practical purpose.

331. The Chief of Ordnance and the Chief of Engineers were both present when the above statement was made to the committee, and no exception was taken by either of these distinguished officers.

332. Later on in the inquiry, while I was relating to the committee the wonderful effect of a 203-pound shot fired from one of the guns converted by me on Nut Island, which, with a charge of only 40 pounds of powder, passed through 16 inches of iron, General Benét interrupted me by a question, and the following colloquy took place:

333. General BENÉT. Mr. Wiard, have you ever fired a lead shot through iron?
334. Mr. WIARD. No, but I have seen them fired.
335. General BENÉT. You see the penetrating of iron is not such a troublesome thing after all. I remember about twenty years ago, when I was a very young man, a gun that I was experimenting with, and there was a gentleman present who was very anxious to fire a piece of lead through iron, and finally he induced a gentleman who had an iron target to give him a shot. He did not expect, of course, that it would do anything. It was a little cylinder of lead that weighed 33 pounds. I used 8 pounds of powder at a distance of 75 feet, I think, and I put it through 4 inches of iron without any trouble.* So, you see, the penetration of iron is not such a troublesome thing after all.
336. Senator BECK. I thought that the penetration of iron was the greatest difficulty we had with the iron-clad ships of other nations.
337. General BENÉT. It is.
338. Senator BECK. Why do you not use lead instead of iron?
339. General BENÉT. It will not do at all times; it is like driving a candle through a pine door. (Page 18, report of testimony.)

340. And again, page 38, I was interrupted by General Benét. I proceeded to say, in answer to a question by a Senator:

341. Mr. WIARD. I have this objection. The Ordnance Office has never yet fired a large gun rapidly. I propose to fire guns as rapidly as twice a minute.
342. General BENÉT. How large guns?
343. Mr. WIARD. I propose to fire a 10-inch rifle at the rate of twice a minute. I propose to fire a 15-inch rifle at the rate of once a minute, for 30 rounds.
344. General BENÉT. During the war I tried all the guns I could get—24s, 32s, and 42s. I fired them as rapidly as I could; I tried them when it was snowing, and I was walking in snow up to my knees to see whether we could utilize these old guns. We have never been able to do it.
345. Mr. WIARD. It has never been tested.
346. General BENÉT. Firing a gun every two minutes or twice a minute is what we have not been able to do satisfactorily.

347. Now 24s, 32s, and 42s are comparatively small guns; yet it can be seen that the Ordnance Department has never been able "to do it" satisfactorily, or otherwise; not even "*by walking in snow up to the knees*" of the Chief of Ordnance.

348. In giving testimony before the Subcommittee on Appropriations the influence exerted by official patents over the procurement of ordnance was frequently alluded to, first, as follows:

349. Senator ALLISON. Do you want us to legislate on this appropriation bill upon that particular topic?
350. Mr. WIARD. Yes, sir; upon that particular topic about the conversion of guns, the manufacture of four improved breech-loading twelve-inch rifle guns, and experi-

* The United States is indebted to me for ordnance experiments, materials, labor, and money expended to the amount of $444,000. If General Benét will cause this experiment to be repeated, and if he can again penetrate 4 inches of iron with a lead cylinder of 33 pounds' weight with 8 pounds of powder, I will immediately give to the United States a receipt in full for all that is due me.—NORMAN WIARD.

ments. It is that I wish to address you about, and it has connected with it very nearly he same thing that I presented to you once before here; that is, the malign influence hat is exercised over all this subject by the fact that so many officers of the Ordnance Corps are the owners of patents, while one of them, who has patents for the principal guns that are now being made, and covering their principal details, is at the same time a brevet colonel of the United States Army and a lieutenant-colonel of the Ordnance Corps. He is the constructor of ordnance, the president of the Ordnance Board, and he is the colonel in charge of the ordnance agency in New York. In fact, he has more influence over the subject of procuring guns and experiments to determine their quality than the President of the United States, the Secretary of War, the Chief of Ordnance, Congress, and the Supreme Court of the United States, all put together; and yet he is the man whose guns are being taken under his own patents to the exclusion of every other kind that can be presented.

351. Senator ALLISON. What is this gentleman's name?

352. Mr. WIARD. His name is Silas Crispin.

353. Senator BECK. Is it your complaint that under this provision nobody but officers of the Army, who are themselves to pass upon the experiments, will have anything to do with the matter; that there is no chance to have any other guns used but those they themselves patent?

354. Mr. WIARD. Just so; exactly.

355. Senator BECK. If that is the complaint, it is pretty good cause of complaint, if it is true.

* * * * * * *

356. Senator ALLISON. Allow me to ask you right there, are the smooth-bore guns that are being converted into rifled guns, being converted at the expense of the government?

357. Mr. WIARD. Yes, sir; the government are paying five times as much as I could furnish guns for, and they have not one-half the power my guns have been proved by actual test to have. I have exhibited to you previously official reports which show that I have penetrated with a 9-inch gun a target of 16 inches in thickness of solid iron. One of the series of experiments which I propose is to convert a 10-inch smooth-bore gun, the same as those being converted by the Ordnance Department on my plan, and set it up side by side with a Crispin converted gun, and fire them in competition at iron targets. I do not doubt but that my gun will easily penetrate 15 inches of iron. As my gun is converted at about one-fifth the cost of the Crispin gun and is twice as powerful, and at the same time is adapted to the dimensions of the present casements, and being a combined rifle and smooth-bore, the spherical projectiles on hand, the carriages and casemates can all be utilized. Thus, while furnishing a sufficiently powerful gun, nearly $100,000,000 can be saved to the Treasury.

358. Senator ALLISON. We authorized some new guns to be constructed. Are they being constructed under Crispin's patent?

359. Mr. WIARD. Yes; but another patent. Here it is in the list of patents: "8. Crispin, ordnance, January 16, 1877." It is number 186,308. And here is the official adoption of the same gun, the breech-loader, shown by engraved drawing in the Report of the Chief of Ordnance for 1878, following page 378, and marked Plate 1. It has the official titles of the constructor of ordnance, as in the case last referred to.

360. Senator BECK. Are we making those now?

361. Mr. WIARD. That is the gun.

362. Senator BECK. And the man who is himself determining how the money is expended is the patentee of the gun he is himself making?

363. Mr. WIARD. There is the patent, and here is the adoption of it by the Chief of Ordnance.

364. Senator BECK. Is that fair?

365. Mr. WIARD. If I can read, that is the fact, and it is shown as plainly as it is possible to show anything.

366. Senator ALLISON. That is to say, these heavy breech-loading rifled guns that we are now authorizing to be constructed and which are being constructed, are under the patents of Mr. Crispin, and are being constructed under his direction; do you mean that?

367. Mr. WIARD. Undoubtedly; he is the chief constructor of ordnance.

368. Senator BECK. And has he given a chance to other people, by test, to compete with him, or has he adopted his own without competition?

369. Mr. WIARD. He has adopted his own without any test. There has never been a gun of the kind and caliber fired, and probably never will be, because you appropriated $400,000 in the same words at the last session for the same kind of guns exactly, and you are informed now that they will not be ready for two years. There has not been one of them fired. Now you are asked to appropriate another $400,000 to build the same kind of guns, and it will be four years before they are ready; and before that time Colonel Crispin will invent some other gun, and these will be laid aside as

condemned material, and new guns will be made on the patent. So it will be always, and that is just what I am here to prevent.

370. So much for the guns. Now, the projectiles that are used in them are invented by an officer of the Ordnance Corps. There is a patent issued to J. G. Butler, and here is the official adoption of the same thing. Here is another patent issued to J. G. Butler, and here is the official adoption of it in the report of the Chief of Ordnance.

371. Senator BECK. Are these the projectiles that are being used with that gun?

372. Mr. WIARD. Certainly.

373. Senator BECK. Has any other person been allowed to test projectiles in competition with these, or do you know?

374. Mr. WIARD. I do remember seeing a report in which the Arrick projectile, which is just as good, has been tested, and it was tested without the presence of the inventor, and some little defect in the method or some little falsity in the report made the Butler projectile appear to be the best. In my opinion one is just as good as the other; in fact, the Arrick projectile is a little the cheapest.

375. Senator BECK Are there any other patents there?

376. Mr. WIARD. I have with me twenty-two, but these are the principal ones I wanted to show you, issued to the two officers I speak of.

377. Senator BECK. How many?

378. Mr. WIARD. Twenty-two patents issued to these two officers.

379. Senator BECK. For guns?

380. Mr. WIARD. For material that is required by the War Department—guns, projectiles, cartridges, pistols, and everything, all connected with ordnance.

381. Senator BECK. Twenty-two of them?

382. Mr. WIARD. Twenty-two.

383. Senator BECK. Are these generally in use?

384. Mr. WIARD. I think not. There is something curious about it. These inventions, or what profess to be inventions, are well known devices. They are invented and patented by other people in this and other countries. This breech-loading gun you are now appropriating money for is the Krupp system, with the Broadwell ring or gas check; but then it is patented in this country, and the only difference between the Crispin patent breech-loader and the Krupp gun is that our official pirates use cast iron outside and line inside with a tube, and then apply the Krupp breech-loading arrangement with the Broadwell ring, pirated also, to it, obtain a patent by some underhanded process, after that they adopt it officially.

385. Senator BECK. Does the government pay these officers of the Army for their patents?

386. Mr. WIARD. I do not think that is a thing either you or I can find out; but when I notice the Ordnance Department giving contract to the South Boston Iron Company to manufacture a gun at the price of $46,000 such as I will make for $10,000, it is rather fair for me to suppose that somebody is paid something or make some money on it. That is the highest price ever paid in this country for a gun. The Thompson gun, which has never been tested, although made under the appropriation of 1872, cost but $28,500. It was made by the South Boston Iron Company for this price, and the special plant, tools, and implements necessary for its construction had to be provided at that time. Undoubtedly these things are now being utilized by the South Boston Iron Company in the construction of the Crispin patent gun, which is of the same dimensions, weight, and caliber. The difference in price paid by the government for the two guns is significant. I will make these heavy breech-loading guns for $10,000 apiece.

387. Senator ALLISON. Twelve-inch bores?

388. Mr. WIARD. Yes, sir.

389. Senator ALLISON. Such as are authorized in this bill?

390. Mr. WIARD. Yes, sir; just exactly the same.

391. Senator ALLISON. This is the proposition: "And the manufacturer of four improved breech-loading 12-inch rifle guns." The South Boston Iron Company charges how much?

392. Mr. WIARD. Forty-six thousand dollars each.

393. Senator ALLISON. And do you mean to say you can complete one for $10,000?

394. Mr. WIARD. I can; and I will, a better gun at that price, or not charge anything.

395. Senator ALLISON. That particular gun?

396. Mr. WIARD. No; not the Crispin patent gun; because I do not believe it is a good gun; and because at that price I could not afford to pay royalty that might be charged under the patent. It uses an expanding projectile, and I should fear the gun would not endure the proof with that kind of a shot. I can make a gun for $10,000 that will put a shot through 30 inches of iron. I think I can put it through 30 inches of iron.

397. Senator ALLISON. How long would it take you to build one of those?

398. Mr. WIARD. About six months.

399. Senator ALLISON. A 12-inch gun?

400. Mr. WIARD. Yes, sir. I have the drawings of it here attached to my proposal.

401. Senator ALLISON. Do you mean to say that you would build a 12-inch rifled breech-loading gun for $10,000 that will be a better gun when completed than that one; is that it?

402. Mr. WIARD. I say if you will give me a contract for four guns, I will do them for $10,000 each. I could not go to work and fix up the machinery to make one gun for that without a prospect for future orders; but if you will give me a contract to make four or eight, as this bill, proposes to do for the South Boston Iron Company, I will do them for $10,000 each.

* * * * * * *

403. Senator ALLISON. Very well; let us go on and hear Mr. Wiard, and see what further he has to say.

404. Mr. WIARD. In order to settle the matter as to whether the official constructor of ordnance has patents or not, and whether the guns are being made on his plans, I now exhibit to you a drawing, cut from the Official Gazette. It is patent No. 211,839 dated February 4, 1879, issued to S. Crispin, for a lining tube for ordnance. On the same sheet of paper on which I have pasted this drawing from the official copy of the patent I have also pasted an engraved page from the report of the Chief of Ordnance for 1878. It exhibits the official adoption of this particular plan for lining guns, adopted by the ordnance board, evidently with the approval of the Chief of Ordnance, for it is in his official report, and it is indorsed with the engraved signature of "S. Crispin, Bvt. Col., U. S. A., Lieut. Col. of Ordnance, Constructor of Ordnance." A casual examination of the reports of the Chief of Ordnance for each year from 1872 to the present time will show that a large proportion of all the money appropriated for ordnance experiments from that time to the present has been expended on experiments, printing the voluminous reports, and engravings illustrating this system of converting guns, and all the guns converted from 10-inch and 15-inch smooth bores from 1872 to the present time have been converted according to this patented plan, by which the caliber is reduced to 8 inches, the power of the gun being no greater than is necessary to penetrate 6 inches of iron at one mile range, if so much. It is the largest rifle gun officially adopted for the casemates of the forts, into which no larger gun, on account of their "confined space," can be mounted; yet many years ago it was decided by our ordnance authorities that no smaller gun than a 10-inch rifle would be effective against the iron-clads of that time. The casemate of a fort is essentially the foundation of the fort. If these guns, pronounced by the Chief of Ordnance, General Benét, to be the largest that can find room in the casemates, as he stated to the Military Committee of the House in giving testimony, recorded on page 91, Report H. R. No. 384, Forty-third Congress, first session, when at the same time he stated that a 10-inch rifle was the smallest admissible gun, we come to the conclusion that our ordnance authorities are leading us into the difficulty. That when we have completed an expensive armament of guns of too little power for defense against iron-clads of the future, we must, unless we can find a sufficiently powerful gun of the same dimensions, rebuild our forts, which have cost $100,000,000, in order to find room in the casemates for guns of increased size and commensurate power. Meantime it may be suspected, unless the cupidity of our official inventors should be satisfied, that we may have to renew the armament entirely with guns controlled by later patents issued to officers of the same corps, as far behind the times in effectiveness against the iron-clads of the future as the present patented armament is inadequate for the penetration of the armor of the iron-clads of to-day.

405. Senator BECK. Who is "S. Crispin"?

406. Mr. WIARD. I will read you who he is. I will read you all his titles:

* * * * * * *

407. "SIR: I have the honor to transmit herewith the following papers and plates to accompany your annual report for the current year, viz:

* * * * * * *

"Very respectfully, your obedient servant,
"S. CRISPIN,
"*Brevet Colonel United States Army,*"
"*Lieutenant Colonel of Ordnance,*"
"*Chief of Ordnance Division of the Atlantic,*"
"*Commanding New York Agency,*"
"*President of the Ordnance Board,*" and
"*Constructor of Ordnance.*"

"The CHIEF OF ORDNANCE, U. S. A.,
"*Washington, D. C.*"

* * * * * * *

408. Senator ALLISON. We will hear you now on that matter.

409. Mr. WIARD. Senators, when I appeared before this committee yesterday I believed that sufficient reference had been made to official patents and to official failures to make reliable rifle guns. In my communications and printed correspondence with the War Department, transmitted to the Senate by the Secretary of War, and referred to this committee, as to the official patents to which so much attention was given yesterday, I had at the last session laid before the committee for examination twenty-two patents issued to two officers of the corps, with the suggestion that no other inventor than an official could secure proper attention to his improvements in ordnance while his official competitor might be, and actually was, president of the board sitting in star-chamber conclave to determine upon the adoption of the device for the public service. That I did not magnify the wrong was abundantly proved by the admissions of the Chief of Ordnance yesterday.

410. The hearing before the committee was by this, to me entirely unexpected, interpolation made incomplete and unsatisfactory. I was interrupted almost at the beginning of the reading of my proposal, and it is not yet before the committee.

411. In relation to bursting guns also, I had supposed that that part of the subject was sufficiently disposed of by its treatment in my correspondence with the War Department before referred to—transmitted by the Secretary or War to the Senate, and referred to the committee.

412. In the lists of burst guns thus laid before you, including hundreds, and every kind ever procured by the Ordnance Department, one that burst was the second of the guns converted from a 10-inch smooth-bore by lining with a tube after Colonel Crispin's plan. Notwithstanding that plan was recommended so highly yesterday, the second gun of the kind burst, and it is shown in the reports.

413. General BENÉT. May I interrupt you there?

414. Mr. WIARD. If you please.

415. General BENÉT. I think your remark on that gun is misleading. That gun, in the first place, was not an invention of Colonel Crispin. That was a muzzle-loading gun It was one of two guns that were first made. Of the first two guns that were made, one was lined with wrought iron, the other was lined with steel; both the wrought iron and the steel we had imported from England. When we came to fire the gun that was lined with steel, the steel tube cracked from breech to muzzle at about the one hundred and fiftieth round, and we continued firing it, notwithstanding that, until it burst at about the four hundred and fiftieth round. The one with the wrought-iron tube was fired over seven hundred rounds, and it is good yet. That is the state of that case. It was merely what is known as the Palliser system, that the English Government has been using for years.

416. Mr. WIARD. And yet it is the very system on which I have shown you Colonel Crispin has a patent, and it is the very system Colonel Crispin recommended to the Board of 1872, of which he was a member, and it is the very system on which they are converting guns.

417. General BENÉT. Here, right before me, is the letter of Colonel Crispin to the Board, saying it was the Palliser system, and recommending that it be used.

418. Mr. WIARD. But as soon as it was introduced into the military service of the United States he patented it. That is the whole story about that. It cannot be qualified in any other way except by stating that the gun lined with steel, the strongest material, is the one that burst. The reports show that this gun was lined with a steel tube (much stronger material than iron), as stated by General Benét; yet it burst. Gun No. 1, a weaker one, lined with an iron tube, did not burst. Every one of the lined guns has exhibited enlargements at the seat of the shot, which is a sure indication of approach toward bursting.

419. And I said:

420. A gun and its projectile taken together form an engine as complete in all its parts for the purposes for which it is created as a steam-engine for its duty. If the gun, or if the projectile, from bad design, material, or workmanship, should fail to perform its functions properly, the engine would be inoperative equally whether it was one or the other which failed. The powder used in the gun, like the steam in the other motor, forms one of the three essential elements of the construction. These elements must be adapted to their functions and to each other in one symmetrical whole, else whatever is good in one or even two of the parts may be neutralized, and thus render the engine inoperative. If the pressure of the steam should be so high as to burst the cylinder of the steam-engine, or break the piston, or if the piston, being constructed unskillfully, should change its form, under pressure of the steam, so as to greatly increase the friction, or cause it to wedge or jam itself in the bore of the cylinder, the whole engine might be deranged thereby, or the cylinder might be enlarged in diameter, cracked or burst as effectually as if only the direct pressure of the

steam had destroyed it. The steam-engine has been so far perfected that the piston makes millions of strokes per week for years without the slightest derangement. The friction is reduced to a minimum, and the power which results from the combustion of the fuel is conserved, transmitted, and utilized for the performance of its allotted duty, an achievement of the genius of a long line of patient investigations by inventors and humble mechanics who never sought for or had education, patronage, place, or encouragement from public treasuries.

421. Senator ALLISON. Are these smooth-bore guns sufficiently strong to endure this rifling in the body of the gun?

422. Mr. WIARD. I have no doubt of it whatever. It is supposed that the rifling weakens a gun greatly; but it is well known to persons in the habit of estimating the strength of cylinders subject to an elastic pressure from within, that any tube closed at the ends and subjected to elastic pressure from within has twice the strength to resist transverse rupture that it has to resist longitudinal rupture. If it should burst, it would naturally—by elastic pressure—split lengthwise If the groove of the gun was lengthwise and parallel with the axis of the bore, it would weaken it; but as it goes across the axis in a spiral around the outside, it is nowhere any great distance lengthwise of the gun in the parallel of the axis to the bore. Consequently it affects the gun very little.

423. Senator ALLISON. What is the virtue of your process of rifling—just what you have described?

424. Mr. WIARD. There formerly were two grooves. I now adopt three grooves. *It is in centering the projectile in such a manner that the upsetting of the projectile when the force of the powder acts against it only changes its form very slightly.* If it is a spherical projectile, it shortens its axis, which coincides with the bore of the gun, and increases its diameter [see cut page 70]. * * * The fact is, that in the old method, by the upsetting of the shot which is done in such a short space of time that it indents the bottom of the gun, and does great injury to it, then rebounds and strikes the top, and it goes ballotting up and down until it gets to the muzzle and escapes. *I adopted the plan of supporting the projectile centrally in the bore* [see cut page 146], so that when the shot was inserted the body of the projectile did not touch the gun at all; and if there was any upsetting it was not near the surface of the bore; and if upset sufficiently to touch the bore it would touch it all around alike. The windage was exactly the same at the bottom as at the top.

425. Senator ALLISON. Your system of rifling and your projectile must go hand in hand?

426. Mr. WIARD. Yes.

427. Senator ALLISON. That is to say you have invented a projectile which meets your system of rifling. The one must be a part of the other.

428. Mr. WIARD. It is a mechanical-fit projectile; that is, fits into the rifle grooves, *and has the same form when it comes out that it had when it went in.* It does not change its form permanently in the gun. A projectile that does not permanently change its form in the gun creates no friction, and does not jam in the bore. On the contrary, the expanding projectile is liable to wedge its sabot up between the rigid body of the projectile and the wall of the gun, and has a great tendency to burst it."

429. It was shown plainly that the plan of the ordnance ring was to secure the introduction of the hypothetical Crispin guns into service without any test whatever. The Chief of Ordnance was examined on this point and testified:

430. Senator BECK. But in what is the $400,000 you are now asking to be expended; in building four more guns just like the four you are working at?

431. General BENÉT. That is exactly it.

432. Senator BECK. You do not propose to make any test of any other class of guns, except four of the same character, to make eight instead of four?

433. General BENÉT. That is all; we have four under contract, and four more will be eight. Then we have the other work we are carrying on. We are converting some of the 15-inch guns into 11, 10, and 8-inch rifles.

434. It was a grand conception, as 2,200 guns of that caliber were required according to the project of the ordnance ring—2,200 guns, at $46,000 each, $101,200,000.

435. (J.) The statement armament of the fortifications, appended, is based on information received from the Chief of Engineers, and shows that the number of guns, of all kinds, required to arm our forts, as far as yet determined, amounts to *a total of* 4,181.

To completely arm all the forts, when the character of their armament is hereafter fully determined, will largely increase this total. Of these 4,181 guns, 2,801, including those on hand, *will be needed on the 30th next June. There are on hand,* at the forts and arsenals, 1,659 guns, leaving 1,142 required during the next fiscal year. (Testimony of General S. V. Benét, Chief of Ordnance, U. S. A., page 89, Rep. 384, H. R., Forty-third Congress, first session.)

436. In order to supply the armament already determined upon, 2,200 guns will be required. Taking the 15-inch smooth-bore gun as the basis (15-inch gun made of cast iron, which is the cheapest material), *with carriages and* 100 *rounds of ammunition,* throwing out a good many incidentals, the cost of moving the guns, and also leaving out a number of flank defense howitzers, and many sea-coast mortars, and taking the most economical view of the case, the whole would cost the government not less than $33,000,000. The estimate is made on the basis of the 15-inch smooth-bores, because the armament is to be made up of 12-inch rifles, a far more costly gun, and of 13-inch smooth-bores and 10-inch rifles, which cost nearly as much. If the armament was to be made up of steel guns it would probably cost $100,000,000. (Testimony of General S. V. Benét, Chief of Ordnance, U. S. A., page 91, Rep. 384, H. R., Forty-third Congress, first session.)

437. The price given by Krupp's agent on July 2, 1872, for a 12-inch steel gun and its carriage, delivered at the works in Essen, was $48,500 gold. An armament composed entirely of such guns would, it is believed, cost more than the most expensive fort of modern construction. While, therefore, liberal appropriations are made annually for fortifications, there seems to be strong reason for appropriations of equal magnitude for the armament, when the fact is undeniable that a fort without its proper armament is worse than useless, an inert mass of expensive material without power of attack or defense. (Testimony of General S. V. Benét, page 90, Rep. 384, H. R., Forty-third Congress, first session.)

438. The number of guns which we require on the 1st of next July, on the basis of a 15-inch gun, or its equivalent, is 863, besides 20 mortars and 634 flank defense howitzers. These guns, *with their carriages and* 100 *rounds of ammunition for each,* will cost about $13,000,000, and cast iron is the cheapest material for gun construction that can be used. (Testimony of General S. V. Benét, Chief of Ordnance, U. S. A., pages 91 and 92, Rep. 384, H. R., Forty-third Congress, first session.)

439. We have actually on hand of heavy guns, such as can be used, not over four hundred of the largest size, out of 1,659. The largest proportion of them are 10-inch smooth bores, which are considered too small, and which *are used in casemates, into which the larger guns cannot be placed.* As soon as a suitable rifle gun is adopted, these smooth-bores will give way, because *we can probably put a 10-inch rifle gun to take its place. The casemate 10-inch-smooth-bore is of no earthly use against iron-clads.* (Testimony of General S. V. Benét, Chief of Ordnance, U. S. A., page 91, Rep. 375, H R., Forty-third Congress, first session.)

440. In a memorial I presented to Congress referring to the cost of armament made after the model of 1874—a cast-iron rifle of 12-inch caliber, at a cost of $15,000 for each gun, I said—

441. To your memorialist it seems remarkable that the exact number of guns stated by the Chief of Ordnance to be the number required to complete the armament, at the price it has been estimated by him such guns will cost "*with carriages and* 100 *projectiles for each gun*" (Appendix 3), shall amount to exactly $33,000,000, *without the carriages and projectiles.*

442. In his estimate of the number required "on the 30th June next," 863 in number, for which $13,000,000 is required, we find also, by multiplying 863 by $15,000, *the sum is* $12,945,000, which is about $13,000,000, *and nothing left for "carriages and* 100 *projectiles for each gun."* The Chief of Ordnance further stated, that if the guns were to be made of steel, the cost would be $100,000,000, and it is another coincidence quite as remarkable that 2,200 steel Krupp guns, at $48,500 in gold, delivered at his works, Essen, Prussia, *without the projectiles, should amount to "about* $100,000,000" (Memorial Am. Ord. Co., Senate Mis. Doc., No. 89, Forty-sixth Congress, second session.)

443. Mr. Hunt testifies:

444. Senator BECK. What other payments are made by the United States besides the $46,000, in the way of helping to start and the plant?

445. Mr. HUNT. We told the Chief of Ordnance that we could not afford to put any more money into the plant for the manufacture of ordnance than we had already done; that we had suffered too much in that direction. I told him if he could guarantee enough work to warrant us in doing so I should be ready to do it. He said that was

impracticable. I then told him that if he would pay the cost of such tools as would be required I would agree to redeem them as fast as we had work sufficient to warrant us in doing so. An arrangement of that kind was agreed upon.

446. Senator BECK. To what extent is money to be paid?

447. Mr. HUNT. I think the whole amount will be something like between $50,000 and $60,000; that is, including the manufacture of tools of which the title is in the United States, but we engage to buy them back after we have had a certain amount of work on them. They are the property of the United States until we do redeem them.

448. Senator BECK. So that in addition to $46,000 for each gun, we have to pay $50,000 or $60,000 now for tools?

449. Mr. HUNT. Tools for us to use.

450. Senator BECK. What is your agreement as to the amount of work that is necessary to enable you to pay it back?

451. Mr. HUNT. The arrangement was that we should reserve a sinking fund of five per cent. on all work we did with those tools, and when the sum was sufficient to redeem the tools, the government should have the pay.

452. Senator BECK. How many guns would you have to make in order to do that?

453. Mr. HUNT. I have not gone into that calculation. I do not know. It would depend upon how many guns we made.

454. Senator BECK. Would you have to make twenty?

455. Senator BOOTH. At five per cent., $50,000 would require a million dollars' worth of work?

456. Mr. HUNT. It would be something like that, perhaps more, because the cost to the government is not as much as the cost of the plant. Probably it would be twenty-five.

457. Senator BECK. You would have to make about twenty-five guns in order to pay it back?

458. Mr. HUNT. In order to pay back to the government the money they have invested in those tools.

459. Senator BECK. And if by any accident the Government of the United States should find that some other gun was better, or that somebody else could make it cheaper, that investment of $50,000 or $60,000 is lost to us?

460. Mr. HUNT. I do not know why they could not take their tools if they wanted to use them; they would be suitable for other kinds of guns. The reason why it is necessary to have these tools is because the guns are much heavier and longer than any ever made in this country. If the government continue to make guns of that sort these tools would be entirely suitable for that work, but if they should give up making heavy guns, of course they would not be worth anything except for old material.

461. Senator BECK. They have paid $50,000 already.

462. Mr. HUNT. They are to pay it as fast as the work is finished and completed.

463. Senator BECK. Therefore, in order to make no more than the four guns we have four times $46,000, and $60,000 added, as the cost of four guns, if we quit there?

464. Mr. HUNT. Yes.

465. Senator BECK. Making each gun cost us about $61,000; is that right?

466. Mr. HUNT. I should say so; probably it would be about that.

467. Senator BECK. Colonel Crispin is the chief of what? I do not know.

468. Mr. HUNT. He is the constructor of ordnance.

469. Senator BECK. Is he president of the board that selected your gun?

470. Mr. HUNT. I understand he is. Of my own knowledge, I do not know anything about the board. I have understood that he is president of the board of ordnance officers who decide the kind of guns to adopt.

471. Senator BECK. If his patent turns out to be a valid patent what would be about the royalty you would have to pay?

472. Mr. HUNT. I do not know what he would charge.

473. And General Benét testified:

474. Senator ALLISON. General Benét, you say that you are satisfied that these four twelve-inch guns that you have now contracted for will prove a success?

475. General BENÉT. Yes, sir.

476. Senator ALLISON. Of course it is impossible that any of them should have been tested.

477. General BENÉT. They are not made yet.

478. Senator ALLISON. Have you such faith in them as to believe that it is wise to contract for four more?

479. General BENÉT. Yes, sir. I am willing to do it and to recommend it.

480. Senator ALLISON. You think from experiments with other guns their success so nearly assured that it is a wise thing to proceed with the construction of four more?

481. General BENÉT. I should not have the slightest suggestion of a doubt about it.

482. After hearing the references to the malign influence of official patents in testimony before the Subcommittee on Appropriations, Senate, Mr. Beck said in the hearing of the Chief of Ordnance and the Chief of Engineers—

483. If we are going to expend $400,000 or any other sum for experiments I want to see that we get a chance for the best gun for the money.

484. Senator ALLISON. I agree to that, but here is the trouble with me: *The War Department, under this bill,* can make these experiments; they can, if they choose, *do just what Mr. Wiard has projected;* or, if they cannot, I want to know why they cannot, or what further legislation is necessary. If they can, and will not, *then it becomes necessary for us to provide in this bill a compulsory process;* * * * and now I should like to ask Mr. Wiard———

485. Senator BECK. Before you go on I want to state my difficulty. When the sundry civil bill was up last year, Mr. Wiard and others came before us and wanted some provision made in that bill whereby these experiments could be made. It was at the very heel of the session. We heard very remarkable statements made, which, if true, ought to receive attention, part of which was that the guns that were used were of an inferior order, and were used because they were patented by men inside the department, who were using their own patents to the exclusion of other inventions, and that the board that was making up and determining about these guns were either the inventors or the associates of the inventors; and that a fair hearing was never had by anybody, because of patents inside the department.

486. Now, if we are going to spend four or five hundred thousand dollars, or any other sum, I protest against a ring inside of any bureau of this government running its own patents, and injuring the chance of the government to get the best gun because its officers are seeking to forward inventions of their own. I do not believe in an inventor passing upon the merits of other people's inventions in competition with his own. I want to know about that, and I want the department to tell us about it, because if half the allegations made by Mr. Wiard and others against that management be true, it is time we were either stopping giving them any money, or finding out some better way of having it expended. Whether there is a word of truth in them I do not know; but that is the point I want to get at, and, before appropriating in this very bill this money, I want to have some information that the money already voted is being expended by the department for the best gun, and not to promote the self-interest of men who happen to have the management of affairs. That is the whole theory I have about it.

487. The above remarks by Senators having charge of the fortification bill which had passed the House with another appropriation of $400,000 for four more 12-inch improved breech-loading rifle guns, were not reassuring to the ring, and after the close of the testimony, and previous to reporting the bill, General Benét resorted to the agency of the press for a last word.

HEAVY ORDNANCE FOR HARBORS—GENERAL BENÉT REPLIES TO ATTACKS UPON HIS BUREAU—SUCCESS OF THE TWELVE-INCH GUNS.

[By telegraph to the Tribune.]

488. WASHINGTON, *January* 30.—The subject of heavy guns is still under consideration by the Subcommittee of the Senate Appropriations Committee, consisting of Senators Allison, Beck, and Booth. The subcommittee has given a number of hearings to persons claiming to be inventors of naval guns, who have attacked the ordnance officers of the government. This has necessitated a reply by the ordnance officers. The bill, as passed by the House, appropriates money for the construction of four more twelve-inch breech-loading guns of the kind now under construction for the government. Mr. Norman Wiard and other persons have sought to impress upon the committee the idea that these guns will not prove a success.

489. In view of the attack upon the Ordnance Bureau, General Benét, the Chief of Ordnance, was visited to-night and asked to give some information in regard to the new 12-inch guns. He said: "We have four guns under way now. The first gun will not be finished within a year, and if they want us to take that gun and fire several hundred rounds, the trials would occupy six months. Meanwhile, work on the other three guns would be stopped; for *there is as good reason for stopping work upon them as*

there is for refusing to construct others of the same sort. None of us have any doubt of their success. The system is the same as that we have already amply tested. It is the Krupp system applied to a cast-iron gun. We have every reason to believe that our 12-inch rifle is going to be a success, and *we are willing to stake our reputation upon it.* These guns were ordered to be made by Congress; we did not propose them, but were perfectly willing to undertake them." General Benét thinks that those guns will answer all our wants, and that the government should go ahead and arm all our fortifications. He says they will certainly pierce twenty-five inches of iron at a distance of 3,000 yards, which would be enough to demolish any war ship that can cross the ocean.

490. But the Senate committee amended the bill, nevertheless, and it became law with the following clause included, which was the "compulsory process" threatened by Senator Allison:

491. For the armament of sea-coast fortifications, including heavy guns and howitzers for flank defense, carriages, projectiles, fuses, powder, and implements, their trial and proof, and all necessary expenses incident thereto, and for machine guns, including the conversion of smooth-bore cannon into rifles, three hundred and twenty-five thousand dollars. And the President is authorized to select a board, to consist of one engineer officer, two ordnance officers, and two officers of artillery, whose duty it shall be to make examinations of all inventions of heavy ordnance and improvements of heavy ordnance and projectiles that may be presented to them, including guns now being constructed or converted under direction of the Ordnance Bureau; and the said board shall make detailed report to the Secretary of War, for transmission to Congress, of such examination, with recommendation as to what inventions are worthy of actual test, and the estimated cost of such test; and the sum of twenty-five thousand dollars, or so much thereof as may be necessary, is hereby appropriated for such purpose.

BOSTON HERALD INTERVIEW WITH MR. WM. P. HUNT, PRESIDENT SOUTH BOSTON IRON COMPANY, NOVEMBER 20, 1881.

492. We made a 12-inch breech-loading cannon and an 8-inch one. They were made after what is known as the Crispin design. * * * We used the best imported steel for the work that was obtainable. The rifled tube made of wrought iron. And yet, when the 12-inch gun was taken to the proving grounds at Sandy Hook, after the firing of only a few rounds, the steel breech broke off at its thickest part and blew out. The 8-inch gun, made in the same way, also broke, and its breech blew out after firing a few rounds. This method of gun-making is a very expensive one, the steel breech costing enormously. * * *

493. And in his interview, Mr. Hunt continued in direct contradiction of his testimony before the committee, which was as follows:

494. Senator BECK. I mean of that caliber; the one you are now making.
495. Mr. HUNT. We have made a 12-inch rifle—a muzzle-loader—of that caliber, which has been fired and has proved satisfactory. There is no question as far as that is concerned.

In his interview he says:

496. A series of ominous incidents have occurred in the gun tests. The more or less free opening of welds in every gun tested, and the demoralization of the material at the seat of the charge; the cracking from breech to muzzle of the steel tube and jacket in one of the early converted guns, * * the blowing out of the tube of the 10-inch heavy muzzle-loading rifle at the fourth or fifth fire, through the opening of a defective weld, * * to say nothing of the friction and the enormous power required to tear off the muzzle of the gun, the body of the gun sustaining no apparent injury; *the discontinued proof of the new 12.25-inch rifle after 30 rounds, through fear of a similar accident*; the complete cracking through necessitating early repair of the tube of the 11-inch breech-loading rifle near the seat of the gas-cheek (this gun has since burst, after a few additional rounds, rupturing the steel by blowing out the breech, but without injury to the cast iron); * * the destruction, a few days since, of the new 8-inch converted breech-loader by rupturing at the third fire the heavy steel jacket in its thickest part, the gun body, as usual, being unimpaired. Such a series of accidents or failures cannot certainly by any ingenuity of reasoning be interpreted as complimentary to either the steel or the wrought iron, separately or in combination. * * *

497. The 12.25-inch rifle being the identical gun referred to in his testimony which he said had been fired and proved satisfactory.

498. In his testimony before the committee General Benét said that he "had not the slightest suggestion of a doubt" about the success of the 12-inch Crispin guns, yet he knew they were lined with a coiled welded tube.

499. In report of 1878, page 9, the Chief of Ordnance, General Benét, said of the coils:

500. "Defective welds in the coils are the only elements of weakness, but these defects are grave, as it is impossible always to detect them in the manufacture of the tubes. The *dragging effect of the shot*, as it passes through the bore, under the great propelling force of the powder, *is liable to pull the tube apart at a defective weld and disable the gun.*"

501. Colonel Crispin, also, in the same volume, contributed his testimony as to the failure of the linings of the same guns so highly commended previously by General Benét and himself, as well as by Mr. Hunt, and he said in the same volume of the report of the Chief of Ordnance, page 351: "The difficulties of securing perfect weldings in coiled wrought-iron tubes have led, in some instances in the history of the employment of linings, * * * *to the development of grave accidents in service*, (?) tubes being blown out and the muzzles torn off, all from defective welds."

502. Mr. Hunt in his interview says:

503. * * * The coiled wrought-iron tube is about the worst form to employ, since it is not only altogether deficient in transverse strength, but has a welded spiral line of over 100 feet exposed to the action of the discharge. * * * That the employment of a coiled wrought-iron tube within a heavy steel * * * casting is a combination without justification, and does violence to the well-known physical properties and characteristics of the metals thus combined. * * *

504. Colonel Crispin has three patents in connection with the breech-loading gun—the lining tube, the gas-check or Broadwell ring, and the breech-receiver. As to his expectation of royalty for his invention, he answered, in writing, to the queries of the committee as follows:

505. "Regarding the question "whether or not he has any expectation that he will be paid in the future any royalty for the use of his patent, or if he proposes to make any claim in relation thereto," I have to state that the subject of remuneration for the use of the patent has not been considered by me up to the present time, nor can any decision from me hardly be fairly made until I am fully aware of what is regarded by competent authority as to what is just between myself and the United States Government in the premises."

506. As to competent authority, the royalty for the Rodman patent was awarded in the following order:

"WAR DEPARTMENT, *November* 16, 1859.

507. The Ordnance Bureau will make arrangements with all the founders who are to make heavy ordnance for it, to have all such cannon cast hollow, after the plan called "Rodman's plan." The free use of the right to cast cannon for the land service after this plan will be secured by the Ordnance Bureau to each founder, by the pay-payment for such use for 20 per cent. on the cost of each from the appropriations for the armament of fortifications, to Mr. Charles Knapp, the proprietor of the patent. The price for the finished cannon at the foundries will remain the same as now paid.

J. B. FLOYD,
Secretary of War."

(P. 552, S. Ex. Doc. 72, Thirty-seventh Congress, second session.)

508. And the amount was 20 per cent. for Rodman's one patent. Crispin's three patents were each as much entitled to an award of 20 per cent. as Rodman's one. This would, if paid, make a nice little sum, being 60

per cent. on $101,200,000, the "cost of the product" on 2,200 guns, at $46,000 each, or $66,000,000. Mr. Hunt testified as follows:

509. This invention of Colonel Crispin is a very trifling matter. It does not affect the strength of the gun. It is only a method of working it, for which he may be entitled to a patent. It does not affect the strength of the gun at all. I do not think the endurance of the gun is dependent at all on his device.

510. Senator BECK. With whom did you make the contract?

511. Mr. HUNT. With the Ordnance Department.

512. Senator BECK. Who is that?

513. Mr. HUNT. General Benét.

514. Senator BECK. You had nothing to do with the board of which Colonel Crispin is chairman in making the contract?

515. Mr. HUNT. No, sir; I did not even know that board.

516. Senator BECK. Did you make the contract yourself?

517. Mr. HUNT. I signed the contract.

518. Senator BECK. You as president of the company signed it. Did you make the negotiation?

519. Mr. HUNT. I made the negotiation. I wrote the letters. It was done largely by correspondence as well as by personal interviews, and it was done by me.

520. Whereas an examination of the contracts and correspondence filed in the "Returns Office" shows that the negotiation and the correspondence, mostly passed between Colonel Crispin and himself, Colonel Crispin being president of the Ordnance Board and constructor of ordnance.

521. While the Senate subcommittee had the fortification bill, which afterwards became law (Public act No. 69, approved March 3, 1881), I presented estimates for the cost of converting 1,600 of the guns on hand into combined rifle and smooth-bores adapted to my improved spiral triangular sub-caliber, centered mechanical fit projectiles, with a cutting point and chilled, to the committee. The total cost of 1,600 guns so converted was only $800,000, while, as has been seen, the cost of 2,200 Crispin guns, far less powerful for the penetration of iron defenses, of less range and general efficiency, being entirely without any fixed rate of endurance, amounted to the enormous sum of $101,200,000: And I asked the attention of the committee to the following statement.

WASHINGTON, *January* 20, 1881.

522. SENATORS: I ask your attention to the results I have heretofore obtained while firing ordnance converted from smooth-bore Rodman guns to "combined rifle and smooth-bores" by simply rifling the original bore, without lining, or reducing the caliber, as shown to you in my testimony.

523. By this process of conversion the following advantages may be secured, and have been secured, as the result of practical experiments have demonstrated, and as the official reports show:

524. First. The power of the gun is more than quadrupled.

525. Second. The cost of conversion is but one-fourth as great as by the Crispin patented plan or the Palliser system.

526. Third The time required for the conversion of all the 10 and 15 inch Rodman guns on hand (about 1,600 in number) is immeasurably shorter—six months instead of one hundred and seventy-five years.

527. Fourth. The spherical projectiles on hand can be utilized, and for certain kinds of practice these are more effective than the more expensive rifle projectiles.

528. Fifth. The capacity of the bore remaining unreduced, the advantages resulting from the use of powder of the improved form, with increased size and density of grain, can be better secured.

529. Sixth. The gun will have better endurance.

530. Seventh. The guns by this mode of conversion become combined rifle and smooth-bores, and are adapted to the lenticular or spiral, triangular, sub-caliber, mechanical fit, centered projectiles, and also to the spherical kinds.

531. Eighth. The gun by this mode of conversion is not injured for the other mode of conversion, patented by Colonel Crispin, nor for another mode of conversion and manner of mounting, invented by myself, by which its power can again be greatly increased, and the rapidity of fire and power in foot-pounds for given time of practice improved and increased.

* * * * * * *

532. Heretofore only one condition affecting the value of an armament composed of a limited number of guns mounted in a fort has been considered indispensable for defense, viz, the power of the guns to penetrate the greatest possible thickness of iron armor protecting the sides of the ships of the enemy by which we may be assailed; and our ordnance authorities seem to contemplate making up for the acknowledged *slowness of fire or slow repetition by each gun*, by the number of guns estimated for, and for which emplacements have been provided by the engineers. *Undoubtedly the gun which could deliver five equally effective shots in the same time another one delivers one, would be five times as effective in battle as its slower competitor.*

533. The 15-inch long bored breech-loading gun referred to in the proposal printed with the testimony taken by the committee, is intended to fire five shots, while the "improved breech-loading 12-inch rifle of Colonel Crispin" delivers one!

534. It can be seen that my gun is devised to reduce the friction of the projectile as it passes out of the bore as much as possible, and I do not doubt can be fired five shots with its mechanical fit projectile without heating the gun as much as *one* shot with the Crispin gun, using an expanding projectile, would heat his gun; so that my gun would have no greater tendency to burst from "unequal expansion of its metal," when firing so rapidly, than the Crispin gun would have when firing at its slower rate.

535. My carriage (shown by drawings which accompany my proposal) is specially devised to secure facility for rapid repetition of shots. By its operation, *the gun is run forward again* to the position in which, being a breech-loader, its charge is inserted, and at which it is fired again, automatically, and *in the same time* required by the Crispin gun *to complete its recoil*. The heavy Crispin gun then requires the utmost effort of fifteen or twenty men to run it forward to its proper position for loading, by which much time is wasted. The operation of loading the gun cannot begin until this laborious process of running the gun forward has been completed, thus but one-fifth of the number of guns are required, and but one-fourth the number of men for each of the reduced number of guns.

536. Now, therefore, if it is true, as it seems to have been proven to the committee and assented to by Gen. Benét, that we can, by improving the form, density, and size of the grains of powder so as to adapt it to the strength of the material of which the gun is made so that the gun will not burst, "*even if made of cast iron*," by the force of the direct pressure of the powder, securing, at the same time, higher velocity to the projectile; and if we can, by reducing the friction of the projectile by making it slide smoothly out of the guns so that we reduce the rate of heating to less than one-fifth, why can we not fire five shots by the new method while one can be delivered after the old time-honored mode? If we can fire five times as many shots in an hour by the new appliances, the new gun and new projectile, and produce the new guns of double the power for one-fifth the price of the other, procurable, too, in the one-hundredth part of the time, why should we buy five of the less effective guns instead of one of the cheaper ones, guns such as we can get so much quicker also?

537. In other words, why should the United States purchase 2,200 new guns at $46,000 each, with 100 expensive projectiles and a carriage for each, besides converting 1,600 guns on hand expensively to make up the 4,000 reported as required, at a cost of $157,741,950, when we can, by converting the 1,600 guns on hand, according to the new plan, procure more effective armament, all complete, for which the carriages and a part of the projectiles are already on hand, for $800,000?

* * * * * * *

538. To the above-enumerated guns, 300 more can be added by converting the Parrott rifles and 8-inch guns on hand, and supplying for each gun 50 spiral triangular projectiles and 50 spherical shells for each gun, thus making up an armament far more powerful and effective than the one made up of 4,000 guns, as contemplated and recommended by the ordnance authorities.

539. It is confidently believed that the 15-inch gun in the proposal and specification referred to can penetrate 30 inches of iron, at one mile range, if constructed according to the plan described; and if at the first trial they should not, it is almost certain that by further increase in the length of the bore (in a manner that is obvious), and by further increasing the size and density of the powder-grains (which it is also obvious can be done), the necessary power can be secured without additional strain upon the gun.

540. That the 15-inch gun can be fired as rapidly as one round every two minutes for 15 consecutive rounds, which rate of rapidity is five times as great as the Crispin 12-inch breech-loading rifle can be fired, and that it can penetrate twice the thickness of iron at one mile range, is not to be doubted.

541. It is believed that it is not possible to operate a gun of the necessary length and capacity of bore to give so high a velocity and such great power, if mounted in the ordinary manner—to be elevated and depressed by turning on its trunnions. The recoil would be on a different plane from the plane of the bore. The recoil of my gun on its improved carriage is in the direction which coincides with the plane of the

bore. A much smaller port-hole, or opening for the muzzle to protude through, is therefore required for my gun than for any other in use in the United States or in any other service. Therefore, I do not fear competition with the Crispin gun in any possible modification, such as increase of length; while to my gun there is no practical limit to the length to which I may extend the bore by lengthening the chase, except the length, to which it would give no advantage in utilizing the expansion of the gases of slower burning powder.

542. Besides, my projectile has a *sub-caliber* puncturing point and body, and makes its hole through the target only of one-half the area of cross-section of the bore of the gun, and has the very best form of point for penetration. For these reasons, if I could offer no other, I would, even from a theoretical point of view, be justified in claiming double the work of penetration with the same caliber of gun; or, to state it more correctly, the same penetration with half the charge of the same kind of powder.

543. My best 10-inch rifle, converted from a 10-inch smooth-bore Rodman, will, it is lieved, penetrate through 22 inches of iron at one mile range; and, it is believed, prove capable of delivering thirty consecutive shots in thirty consecutive minutes, which *is five times as rapidly as any other gun in the world can deliver 500-pound projectiles.* It will have the advantages claimed for the 15-inch gun within its sphere, and thus by the adoption of this plan of converting 1,300 guns of those on hand of the two calibers, the government will be put in possession of an armament capable of delivering 19,500 *tons of projectiles an hour,* while the Ordnance Department armament of 4,000 guns, at the rate of rapidity of fire attributed to the guns, *can deliver but* 5,675 *tons of projectiles per hour.*

Very respectfully, &c.,

NORMAN WIARD.

The SUBCOMMITTEE ON APPROPRIATIONS,
In charge of the fortification bill, United States Senate.

NORMAN WIARD'S PROPOSAL.

WASHINGTON, D. C., *January* 10, 1883.

To the Senate Select Committee on Ordnance:

544. Norman Wiard, of Washington, D. C., party of the first part, proposes to provide armament for the sea-coast fortifications, heavy guns, carriages, projectiles, powder, implements, trial and proof, the necessary incidental expenses thereto, and to convert smooth-bore cannon into rifles, according to the terms of the following specifications, and for the considerations hereinafter named.

SPECIFICATION "FOR ARMAMENT OF THE SEA-COAST FORTIFICATIONS," "HEAVY GUNS."

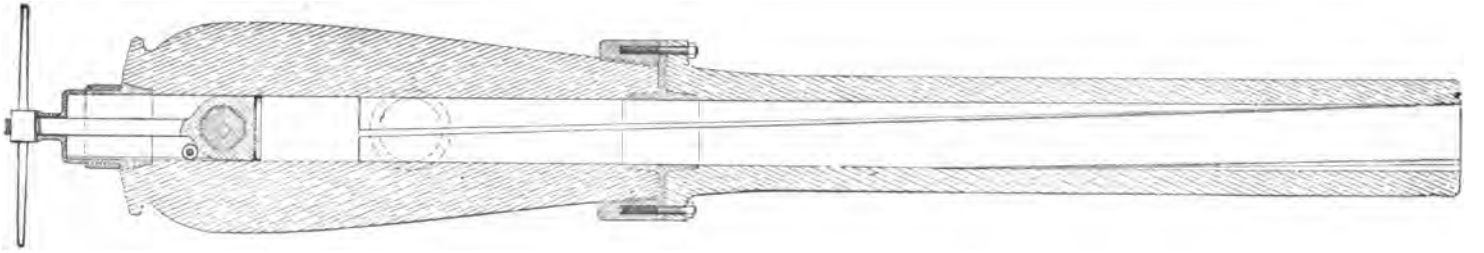
545. First. The party of the first part will produce by conversion and deliver to the War Department, after trial and proof, four long-bored breech-loading Wiard rifled guns, converted from 15-inch smooth-bore Rodman guns, supplied, as hereinafter stipulated, by the War Department from stock on hand, in the manner it has heretofore been the practice to supply smooth-bore guns for conversion. The plan of conversion to be followed is shown by tracings of drawings hereto attached, marked A and B.

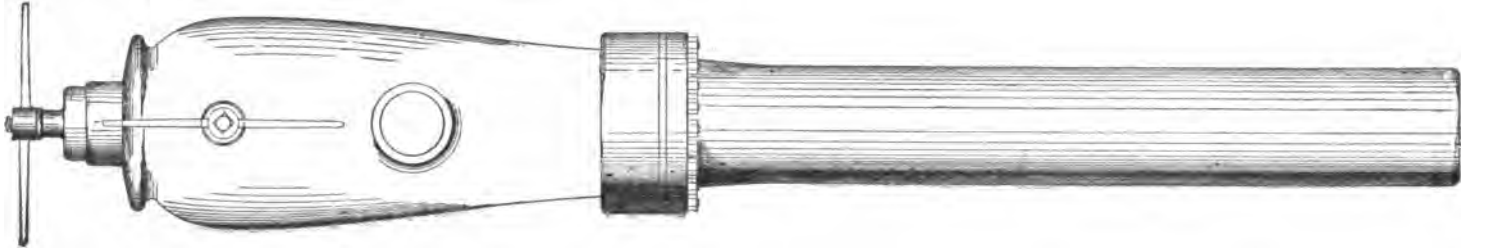
546. The drawing A shows a rifled gun of 15-inch caliber, converted from a 15-inch smooth-bore, and B a rifled gun of 12-inch caliber with a chamber converted also from a 15-inch smooth-bore. One of each kind will be prepared, and after trial and proof the War Department may elect which of the two calibers shall be adopted for the four guns to be converted and delivered for armament of the sea-coast fortifications in the fulfillment of this part of the specification.

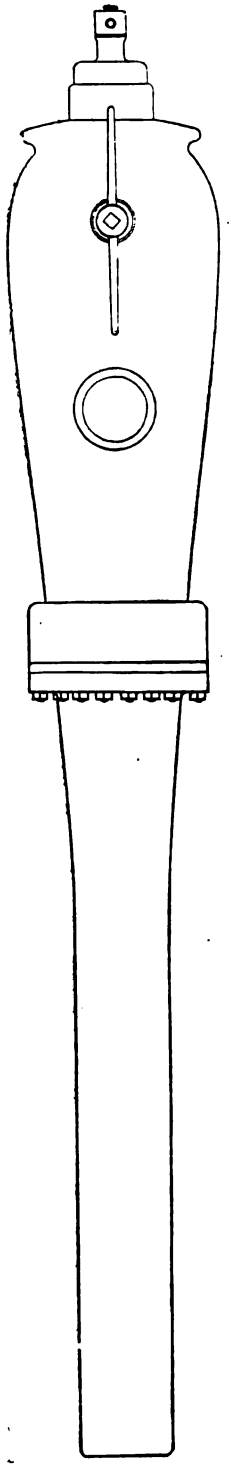
547. Second. The party of the first part will also produce by conversion and deliver to the War Department, after trial and proof, one long-bored breech-loading rifled gun, converted from a 10-inch smooth-bore Rodman gun supplied by the War Department. The general plan of

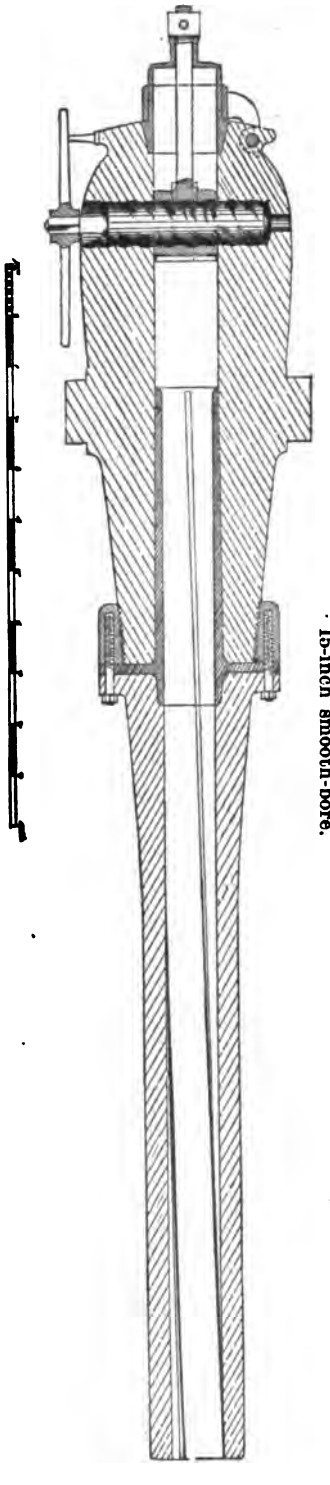
A

Norman Wiard's long breech loading 15 inch rifled guns with cast-iron chase—improved—converted from a "Rodman" 15-inch smooth-bore.









B

Norman Wiard's long chambered breech-loading 12-inch rifle gun with steel lining and cast-iron chase—improved—converted from a Rodman 15-inch smooth-bore.

conversion to be followed will be the same as shown by one of the drawings A or B, and the War Department may elect whether the rifled gun shall be of 10-inch caliber when delivered, or of 8-inch caliber with a chamber, after the trial and proof of the guns converted from 15-inch smooth-bores previously specified has terminated.

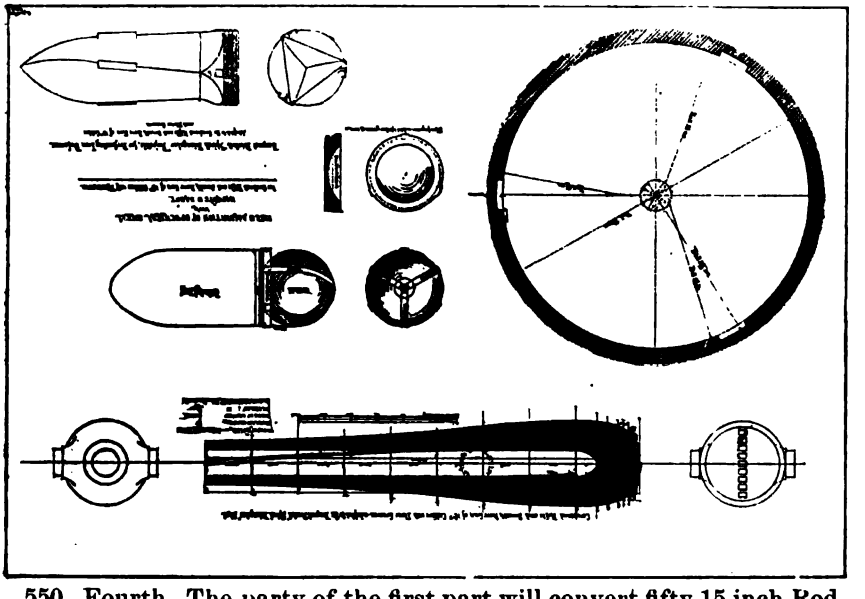
548. The party making this proposal will generally follow the plan of conversions shown by the drawings, but that such modifications of the details may be adopted during manufacture, conversion, or progress of the trial and proofs, as in the judgment of the inventor may be deemed advisable.

SPECIFICATION FOR CONVERSION OF 200 SMOOTH-BORE CANNON INTO RIFLES.

549. Third. The party of the first part will convert one hundred 10-inch smooth-bore Rodman guns, to be supplied by the War Department in the manner heretofore stipulated—with regard to the guns previously referred to—into muzzle-loading "Wiard combined rifle and smooth-bore guns," by rifling them with three grooves each, after the plan shown by the drawing hereto attached and marked C. These guns after conversion will be adapted to the dimensions of the casemates of the forts, the carriages, implements, and spherical projectiles on hand.

C.

Combined Rifle and Smooth-Bore Gun of 10-inch calibre, with three grooves, adapted to the bayonet-pointed "spiral triangular" shot.



550. Fourth. The party of the first part will convert fifty 15-inch Rodman smooth bore guns into "Wiard muzzle-loading combined rifle and smooth-bore guns" of 15-inch caliber, according to the plan shown by drawing C, adapted to carriages and spherical projectiles on hand.

551. Fifth. The party of the first part will convert ten Parrott 10-inch rifle guns into 11-inch Wiard-Parrott muzzle loading combined rifle and smooth-bore guns.

552. Sixth. The party of the first part will convert ten 8-inch Parrott rifles into 9-inch Wiard-Parrott muzzle-loading combined rifle and smooth-bores, by rifling them in the same manner.

553. Seventh. The party of the first part will convert ten Parrott 100-pound rifle guns into 7-inch Wiard-Parrott muzzle-loading combined rifle and smooth-bore guns.

554. Eighth. The party of the first part will convert ten of the guns heretofore converted into 8-inch rifles from 10-inch smooth-bores, by lining with a tube (after Colonel Crispin's patented plan) into 9-inch Wiard-Crispin muzzle-loading combined rifle and smooth-bore guns.

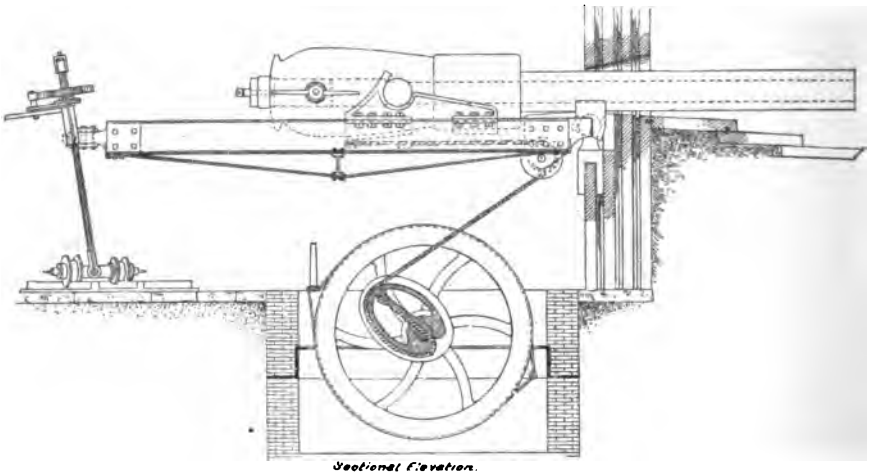
555. Ninth. The party of the first part will convert ten smooth-bore 8-inch Rodman guns into Wiard muzzle-loading combined rifle and smooth-bore guns of 8-inch caliber. All the guns referred to in articles of specification from fifth to ninth will be adapted after conversion to carriages on hand and to spherical projectiles.

SPECIFICATION FOR CARRIAGES.

556. Tenth. The party of the first part will manufacture and supply four wrought-iron automatic carriages with all the machinery and appliances

D.

Norman Wiard's Improved Breech-loading 12 in Rifled gun
Converted from a Rodman 15 in Smooth-bore
with the improved Carriage, Recoil restraining ropes, and device for running the gun forward automatically.



Sectional Elevation.

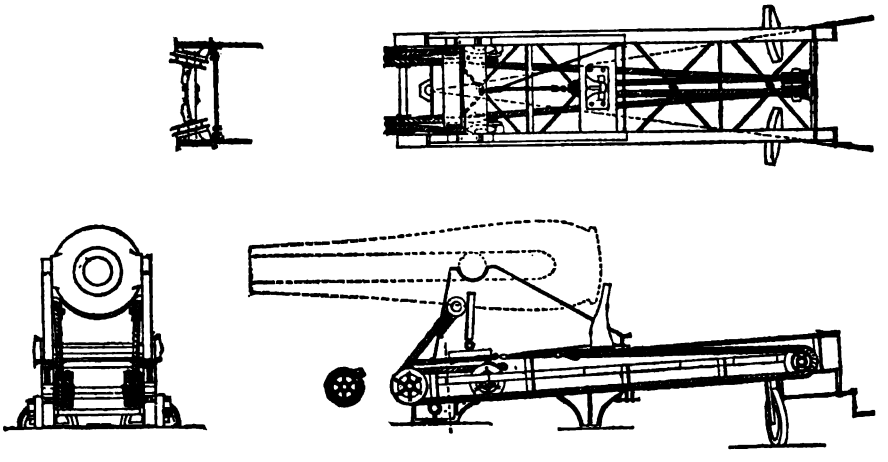
thereto belonging, as shown by the drawing hereto attached and marked D, for and adapted to the four long-bored breech-loading rifle guns referred to in the first article of specification in this proposal.

557. Eleventh. The party of the first part will manufacture and supply one wrought-iron automatic carriage with all the machinery and appliances thereto belonging, as shown by the drawing attached hereto marked D, for, and adapted to, the gun referred to and described in article "second" of specification in this proposal.

558. Twelfth. The party of the first part will make all the repairs, modifications, adaptations, and additions to the carriages supplied as stipulated hereinafter by the War Department, for mounting the Thompson, Sutcliffe, Mann, Lyman, and Crispin gun for competitive trial and proof, and set up one of the carriages on the floating battery, for the trial or proof of a gun, and supply and apply the snubbing-rope plan for re-

straining recoil, made in accordance with the drawing attached hereto marked E, and will supply the floating battery built according to the

E.



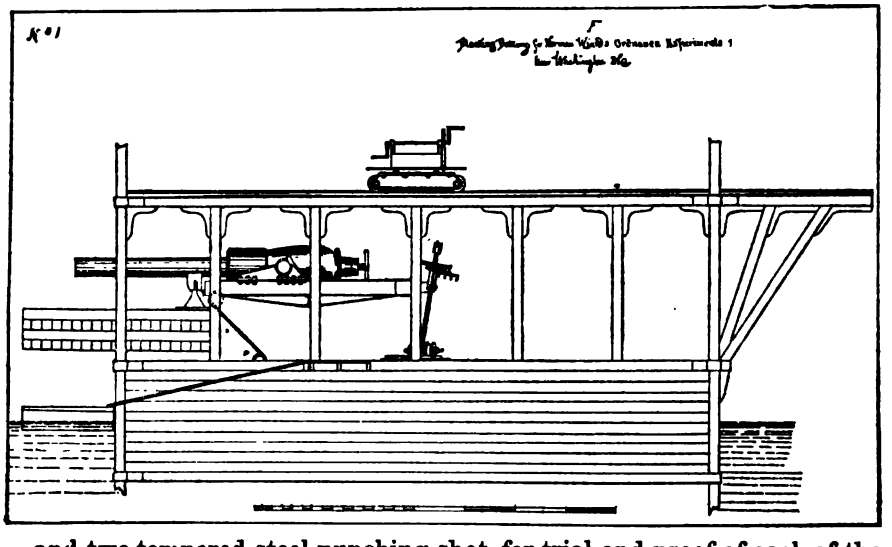
Snubbing Rope for Restraining Recoil.

design shown by the drawing attached hereto marked F, for use dur all the operations of trial and proof.

SPECIFICATIONS FOR PROJECTILES.

559. Thirteenth. The party of the first part will manufacture and supply forty chilled iron, spiral triangular, subcaliber, centered projectiles,

F.



and two tempered steel punching shot, for trial and proof of each of the different calibers of the guns above specified;

560. Fourteenth. Five spiral triangular shells for each different kind and caliber of gun; and

561. Fifteenth. Five spherical shells for each different kind and caliber of gun.

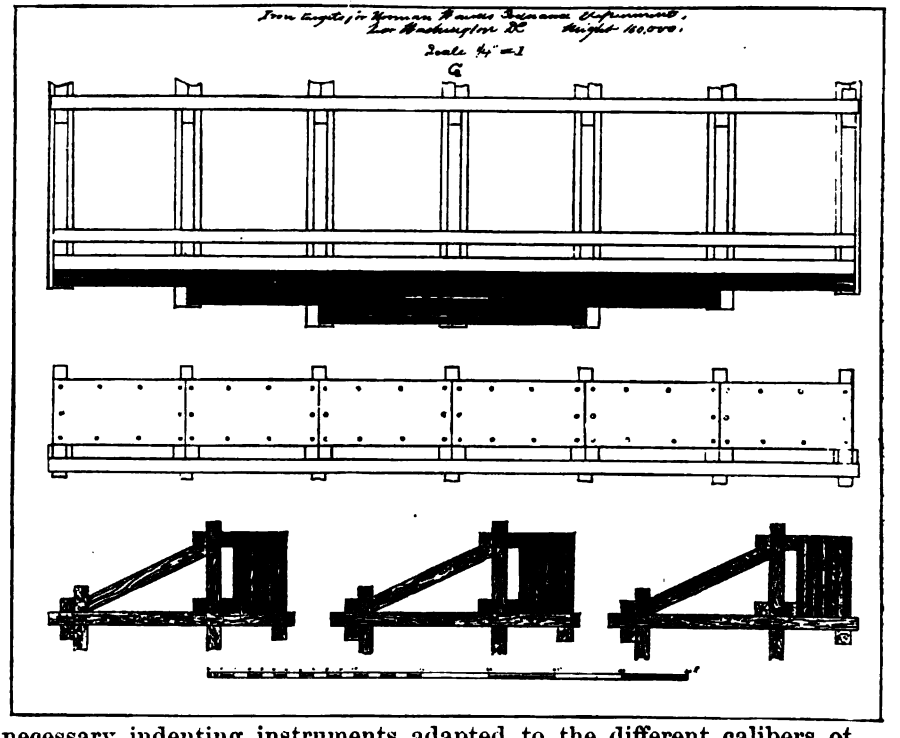
SPECIFICATION FOR POWDER.

562. Sixteenth. The party of the first part will furnish all the powder of various form, size, and density of grain required—not less than ten different sizes of grain, not less than five different densities, and not less than four different forms of grain—with a view to adapting the powder to the various calibers and capacities of the bores of the guns, so far as practicable, to secure the highest velocity to the projectile with the least strain upon the gun.

SPECIFICATION FOR IMPLEMENTS AND NECESSARY INCIDENTAL EXPENSES.

563. Seventeenth. The party of the first part will supply all the implements required for trial and proof of the guns referred to above (except a Le Boulenge chronograph), batteries, conducting-wires, screens, the

G.



necessary indenting instruments adapted to the different calibers of guns for determining the pressure of powder, including laborers' and mechanics' tools, screw and hydraulic jacks, chains, rope, tackle, small boats, barges, and lighters, and provided for all the necessary expenses attending the procurement of transportation, labor, materials, subsistence and ordnance stores, including an iron target, to be composed of twenty-four iron plates, each to weigh about 10,000 pounds, to be each 10 feet long, 5 feet wide, and 5 inches thick, to be set up on the bank of the Potomac River near Washington, firmly bolted together and attached to a

strong frame of wood, as shown by the drawing herewith, marked G. The aggregate weight of the iron plates of the target will be about 240,000 pounds, and in joining them together three inches of wood will be sandwiched between the plates. The target will present 300 square feet of front surface, of which 100 square feet will be 30 inches of solid iron in thickness, 100 feet 20 inches thickness, and 100 feet 10 inches thickness.

SPECIFICATION FOR TRIAL AND PROOF.

564. Eighteenth. The party of the first part will mount the guns on the floating battery, and subject them to trial and proof in the following manner, viz: one of each kind and caliber of gun referred to in this proposal will first be fired the necessary number of rounds, using its proper projectile, and with charges of powder, of different sizes, densities, and form of grain, to determine which of the various kinds tried gives the highest velocity to the projectile, with the lowest strain upon the gun; beginning with the largest grains and greatest densities, and testing powder of reduced density and size of grain in succession, till the proper constitution of the charge is determined to the satisfaction of the inventor of the gun, or the person, or persons, who may have it in charge. Second. A few rounds with the selected powder and approved projectiles to determine the average initial velocity of the projectile, and its average penetration in sand, gravel, or earth. Third. Not less than ten rounds at longer range, to determine the relative precision. Fourth. One, two, or more rounds at the iron target, to determine the power of the gun for the penetration of iron defenses, and to determine the relative value of chilled iron and steel shot. Fifth. From two to ten rounds for range. Sixth. From two to ten rounds with shells of the spherical kind, and an equal number of rifled shells. Seventh. For "proof," thirty consecutive rounds fired with the greatest practical rapidity. A complete record of all the firing, as to initial velocity, power, range, precision, rapidity of fire, character of powder, projectile, carriage, implements, objective point, and general result, witnesses present, and all the conditions usually recorded as fully as possible in writing, as well as by photography, all to be certified to officially, so that the reviewing authority and all persons interested may have full information of the progress and results of trial and proof, and that all necessary and useful information may be recorded for the use of the government, and parties interested in ordnance.

SPECIFICATION OF CONSIDERATION.

565. First. The War Department, party of the second part, shall supply all the guns and carriages specified and necessary for mounting the guns produced wholly or in part by conversion, for armament, and heavy guns, as well as those provided by conversion for trial and proof for armament, in the casemates or *en barbette*, including "one improved breech-loading 12-inch rifled gun," one gun converted from a 15-inch Rodman smooth-bore, and two converted from 10-inch Rodman smooth-bores by lining with a tube, after Colonel Crispin's patented plans; one 8-inch rifled breech-loader, converted from a 10-inch smooth-bore, after Colonel Crispin's patented plans; one Thompson breech-loading 12-inch rifled gun, one Woodbridge gun, one Sutcliffe gun, and one Mann gun, all of the largest calibers on hand, together with the carriages which have to be altered, improved, or modified, and such as may be necessary for mounting the guns, to be mounted on the floating battery for trial and proof.

566. Second. The War Department shall furnish all the projectiles of

"expanding kinds" required, and the necessary quantity and quality of powder for the trial and proof of all the guns, breech and muzzle loaders—other than those rifled or converted according to the Wiard system—in such manner as may be approved or designated by the inventors of the guns, or the War Department.

567. Third. The War Department shall direct the board, which was to be appointed by the President, under the act approved March 3, 1881 (Public No. 69), or some other board satisfactory to him, to be present, take cognizance of, inspect and record all the supplies and the operations, and selection of guns to be manufactured into armament, including heavy guns, and guns to be converted or subjected to trial and proof; to take cognizance of, record and report all the operations connected with the production of guns, conversion of guns, carriages, projectiles, powder, implements, transportation, labor, trial and proof of all the guns and ordnance referred to in this proposal.

568. Fourth. The War Department shall supply for use during trial and proof a Le Boulenge chronograph, and detail one or more approved officers to be present, to take and record the velocities of all the shots fired during the trial and proof.

569. Fifth. The War Department shall give permission and authority to enter upon the land of the reservation at or near Fort Foote, on the bank of the Potomac, near Washington, for the landing of materials, workmen, &c., for the erection of targets, quarters, bomb-proofs, magazines, &c., and its occupation during the time of preparation for or continuance of trial and proof, with ample time afterwards for the operations of removing the same, and restoring the grounds practically to their original condition, if necessary.

570. Sixth. If it shall be found from an examination of the facts of the reports, unqualified by mere opinions, that the guns provided by the party of the first part are more powerful, have equal or better endurance, are susceptible of being fired more rapidly, and are cheaper than any others of like caliber submitted to trial and proof, or known to the War Department, the facts shall be submitted to Congress for its information.

571. Seventh. As a full consideration for the ordnance supplied, materials furnished, money and labor expended by the party of the first part, the War Department shall cause to be paid to the party of the first part the sum of $300,000, which money shall be paid in the usual manner, as work is performed, deliveries made, materials or ordnance supplied, or expenses incurred upon estimates; and when the trial and proof has been completed, and the two hundred and five heavy guns for armament, including converted guns, have all been delivered in accordance with the terms of agreement, all the balance of the aforesaid sum of $300,000 shall be immediately paid over to the party of the first part; and, in addition thereto, the floating battery, all that is left unused and unexpended of targets, projectiles, implements, materials, ordnance, burst guns, or *débris* of the same, or guns and cannons converted, altered, or *débris* of the same, or provided by the party of the first part, shall be turned over to or remain the property of the party of the first part, to be used or disposed of according to his discretion.

Respectfully, your obedient servant,

NORMAN WIARD.

572. I further propose to modify the terms of the above proposal in accordance with a suggestion made to me by the Hon. Robert T. Lincoln, in December, 1881, but am willing to accept the terms of either. By these modifications I now propose to divide the experimental part of the operations under the previous proposal into *four parts*, with a view to ob-

taining specific results as the trial and proof progresses. So that one point of excellence of the proposed "armament," "heavy guns," "converted guns," and "*ordnance*" will be fully settled and determined before I begin with another, or involve the government in needless expense.

573. The *first part* of the experimental operations will begin with and include the furnishing by the party of the first part of powder (and the firing necessary to the selection of the desirable kinds to be used) in accordance with the terms of the original proposal in articles 16 and 18 for the two calibers to be tested in the first part of these experimental operations.

574. The best width and depth of the grooves, together with the best pitch of the rifling for these calibers with the original length of bores unchanged.

575. To thoroughly testing the *power* of the two calibers of guns referred to, *for the penetration of iron targets* and *of "earth-works"* when converted to combined rifle and smooth-bores according to the plan specified in articles of specification for conversion "*third*" and "*fourth.*"

576. To apply and test the snubbing-rope plan of restraining the recoil, and the test and record of the "initial velocities" of all the projectiles fired during *this part* of the experiments, with charges of powder varying from 50 to 100 pounds (being the service and battering charges) for the 15-inch caliber, and from 20 to 60 pounds, the corresponding charges for the 10-inch gun.

577. For this part of the experiments it will be necessary that the party of the first part shall supply all the following in conformity with the terms of the specification in the original proposal, viz:

578. "The floating battery," of which the estimated cost is	$15,000
Two sections of the "iron targets," one (for the test of power of the 15-inch guns) to be composed of three 5-inch plates, 10,000 pounds each, 15 inches thickness of iron to be penetrated, to weigh about 30,000 pounds; one for the test of power of the 10-inch gun, to be composed of two plates, to weigh 20,000 pounds, assembled and set up, with strong wooden frame and backing, as specified in the original proposal, the estimated cost of which is	7,500
"Conversion" of four guns, together with the special tools and plant required	15,000
The application of "the snubbing-rope plan" of restraining recoil, including original patterns and special appliances required for an original production and application	2,500
The experimental powder and special appliances for its production	5,000
"Steel," "chilled iron," and "spherical" projectiles, with patterns, chills, special tools, &c	10,000
Erection, materials and labor for; the renewal and repair of the "sand butt"	5,000
Superintendence, labor, transportation, towing, photographing, and subsistence	7,500
Implements and unenumerated supplies	5,000
Incidental	2,500
Total	75,000

579. And it will be necessary that the War Department, party of the second part, shall, in addition to the money consideration, deliver to the party of the first part the following, viz:

580. Two 15-inch smooth-bore, uninjured Rodman guns of the best quality. Those cast at South Boston previous to 1868, and mounted in the fortifications without having been fired—guns annealed by age—are preferred, and in determining what particular guns are to be selected the experimenter stipulates that the official record of all the 10-inch and 15-inch guns cast at South Boston, and on hand, shall be open to his examination, from which, and upon an actual inspection of the guns, he will choose the experimental ones.

581. Two 10-inch smooth-bore Rodman guns to be selected as above, and four wrought-iron carriages, two for the 15-inch guns and two for 10-inch guns, one of each size to be supplied with the "pneumatic buffers" for restraining the recoil, and the others, without the buffers, will be supplied with the "snubbing-rope plan" of restraining the recoil, as it is proposed to test the snubbing-rope plan in competition with the "pneumatic buffers" throughout the experimental firing in this first part of the experiments.

582. It is to be noticed that the estimated cost of this *first part* of the experiments amounts to a total of $75,000. But as it is the desire of the party of the first part to retain in possession and ownership, after the experiments are over, the floating battery, the special tools, patterns, chills, appliances, and the ordnance specified in article 7 of the proposal, it is proposed, in accordance with the spirit of the terms of that proposal, to deduct, therefore, from the estimated cost of this part of the experiments, the sum of $25,000 (which it is plainly evident is a larger sum than could be realized from the sale of the same at auction after their use during all the experimental operations).

583. Therefore *the money consideration*, for this first part of the experiments which it is stipulated shall be paid by the War Department, will be only $50,000, which sum it is proposed shall be paid to the party of the first part by the Secretary of War, in the manner provided for in article 7 on fourth page of the proposal, upon the "estimates" hereinbefore written, as materials or labor are furnished, ordnance supplied as specified, expenses are incurred.

584. After charging against each item 33⅓ per cent. for the ordnance, &c., above specified, which, as stipulated, is to be retained as the property of the party of the first part, in lieu of said 33⅓ per cent. of the cost as estimated, and 10 per cent. of the remainder from each payment, may be retained by the Secretary of War, as guarantee that the whole programme of experiments will be fully and faithfully executed; all the specified materials and labor furnished, ordnance supplied, and specified expenses incurred. And when this first part of the experimental operations are completed, in strict accordance with the terms of this amended proposal, all the balance remaining unpaid and withheld, of the full sum of $50,000 in money, in addition to the supplies and ordnance left over and retained by the party of the first part, shall be immediately paid to the party of the first part by the Secretary of War, which full sum of $50,000 shall be accepted by the party of the first part, as the full money consideration for this first part of the experimental operations for determining the power of the two specified calibers of guns after conversion; the most effective of the kinds of powder tested; the best modification of the rifling of the guns, and the merits of the snubbing-rope plan for restraining the recoil of the guns, as specified.

585. The *second part* of the experiments are to be conducted for the purpose of testing, by rapid firing, the endurance of the previously specified two calibers of guns, 10-inch and 15-inch, after conversion, on the plan specified in articles 3 and 4, first page of the proposal, and for "trial and proof" of the 15-inch caliber by firing 500 rounds with deliberation, after the usual mode.

586. The trial and proof of endurance under "rapid firing" shall be conducted by firing the 15-inch gun with centered "mechanical-fit" projectiles, of at least 500 pounds weight each, and with service charges of improved powder—not less than thirty consecutive rounds in sixty minutes; and the 10-inch gun with centered mechanical-fit projectiles of not

less than 250 pounds weight each, and with service charges of powder, not less than thirty rounds consecutively in forty minutes.

587. For the purposes of this experiment it will be necessary for the War Department to supply one 15-inch smooth-bore Rodman gun (or two, if one or either caliber shall be disabled before the experiments terminate), and one 10-inch smooth-bore Rodman gun (these to be selected from guns on hand in the manner previously provided for), and the party of the first part will convert the guns to combined rifle and smooth-bore, according to the plans specified in articles 3 and 4 of the proposal, and the photographic page of drawings therewith, marked C, and will supply all the necessary powder, projectiles, implements, tools, materials, labor, transportation, &c., for all the experimental and proof-firing.

588. Five hundred and sixty rounds, it can be seen, will be fired in carrying out this part of the programme, and it is estimated that each round so fired will cost at least $100=$56,000.

589. The property left over after the experiments, which, it is stipulated, shall revert to and become the property of the party of the first part, after the trial and proof is over, as is provided for in relation to these items, in the first part of the experiments, will not, it is believed, sell at auction for more than $6,000. Therefore it is proposed that the sum of $50,000 shall be the price fixed for conducting this second part of the experiments, to be paid by the War Department to the party of the first part in the same manner as is stipulated in relation to the first part of these experiments, 10 per cent. as before to be reserved by the War Department as guarantee that the party of the first part will faithfully perform all the conditions required by the programme for this second part of the experiments.

590. The *third part* of the experimental operations shall be confined to the conversion, trial, and proof of power for the penetration of iron targets and earthworks, of two 15-inch smooth-bore Rodman guns into long-bore breech-loading rifled guns, such as are described in article 1 of the specification in the proposal, and one 10-inch gun of the kind described in article 2, page 1 of the proposal, and automatic carriages for the same, one of the guns (15-inch) to be converted to a 15-inch caliber rifled gun, and one to be converted to a 12-inch rifled gun as described, and for this part of the experimental operations one 15-inch and one 10 inch of the automatic carriages referred to in article 10 of the specification will be supplied by the party of the first part.

591. An iron target composed of six iron plates, each 5 inches thick, 10 feet long, and 5 feet wide, and one composed of four plates for the 10-inch guns, shall be furnished and set up for the experiments as described; being part of the target, equal to a weight of 100,000 pounds described in article 17 of the specifications in the proposal of the 28th of March, 1881.

592. The third part of the trial and proof will begin by experiments to adapt the powder to be used in these long bores and chambered guns to the increased cubical capacity of the bores of each, and will continue by a test of the power of a 15-inch, a 12-inch, and a 10-inch, *or an 8-inch gun*, of this kind, for the penetration of iron defenses, and earth-works; a test of each gun for initial velocity, range, and precision, with shot and shell, rifled and spherical.

593. The average facility afforded for rapid manipulation by the automatic carriages on which the guns will be mounted will also be thoroughly and practically tested; and on the completion of the trials three uninjured guns, in all respects like trial guns—one 15-inch, one 12-inch, and

of 10-*inch or* 8-*inch* caliber, with an automatic carriage for each—will be delivered to the War Department.

594. To carry out this important third part of the experiments it will be necessary that the War Department shall supply to the party of the first part six 15-inch smooth-bore Rodman guns and two 10-inch smooth-bore Rodman guns, to be selected by the party of the first part, in the manner provided for in the specifications for the first part of these experiments.

595. The party of the first part will convert two of the 15-inch smooth-bore guns into long-bored breech-loading rifled guns for trial guns, and all the proof firing will be performed with these; and when the proof and test firing is completed, and such modifications as the result of the trial and proof of these have been determined on, the party of the first part will proceed to convert the remaining four guns on the approved plan. These last to be simply submitted to the ordinary proof, for delivery to the War Department as tested but uninjured guns, in accordance with the terms of articles first and second of the proposal.

596. The estimated cost of the conversion of these guns, eight in number altogether, will be—

597. At the rate of $5,000 per gun	$40,000
Five automatic carriages for same	25,000
100,000 pounds of iron targets, and erection of same	15,000
Powder and projectiles	5,000
Superintendence, labor, transportation, towing, photography, and subsistence	5,000
Unenumerated supplies and incidental expenses	5,000
Total	95,000

598. It is believed that the trial guns, carriages, ordnance, and unexpended supplies left over, to revert to the party of the first part after this third part of the experiments are completed, would not sell at auction for more than $25,000. Therefore it is proposed that the money consideration for this third part of the experiments shall be $70,000, which sum it is proposed shall be paid by the War Department to the party of the first part, in addition to the supplies furnished and left over, which become the property of the party of the first part.

599. The fourth part of the experimental operations is intended to include furnishing all the supplies and all the experimental operations specified in the proposal, and not provided for in the previously specified three parts, and for this fourth part it is proposed that the War Department shall pay to the party of the first part the sum of $30,000, and when all the four parts of the experimental operations are fully completed as specified, and the five guns and carriages are delivered as in the proposal, all the balances reserved and unpaid of $200,000, being the total cost of all the series of experiments, shall be promptly and fully paid to the party of the first part.

600. This amended proposal, it is to be noticed, provides for an additional and expensive test by firing 500 rounds from a 15 inch converted gun not provided for in the proposal.

601. This is intended to be in lieu of the competition firing of the guns lined with a tube made after Colonel Crispin's plan, and the Thompson, the Woodbridge, Sutcliff, and Mann guns, as specified in the first article of specification of consideration on the third page of the proposal. But as all guns lined with steel or coiled and welded tubes are now acknowledged failures, it is believed that the War Department do not desire to have these guns fired at all. Nevertheless, if the War or

Navy Department desire to use the floating battery, the unexpended iron targets, and the appliances already provided for competitive firing between any guns in possession of either department, with any of the Wiard guns provided for in the proposal, the party of the first part will cheerfully give consent to the use of any appliances in his possession at any period during the progress of the experiments, if the number of guns to be so fired shall not exceed five, and no charge will be made against either department for the use of such appliances if the departments furnish the powder and projectiles for all guns it may be proposed to experiment with.

602. If the first part of the experiments referred to in this amended proposal do not show that the 15-inch converted gun with its proper projectile and a powder charge not greater than one hundred pounds is fully capable of penetrating 15 inches of iron through and through, and the 10-inch gun with its proper projectiles of penetrating 10 inches of iron with a powder charge of 60 pounds, then the second part of the experiments need not be proceeded with, and no further expense need be incurred by the War Department on account of the proposal of the 28th of March or of this amended proposal. But if the said gun should prove to have so much power or more, and if during the second part of the experiments the endurance of the guns of 15-inch and 10-inch caliber should be established by the trial and proof of rapid firing, then in that case the War Department shall put the party of the first part in possession of the 200 guns enumerated in the third, fourth, fifth, sixth, seventh, eighth, and ninth articles of specification in the first and second pages of the printed proposal, and the party of the first part shall proceed to convert them as therein proposed in lots of 20 guns each, and the War Department shall pay to the party of the first part for such conversion, at the rate of $500 per gun, promptly upon the completion and delivery of each lot of 20 guns so converted, until all the 200 guns are converted and paid for, and the Secretary of War shall recommend to Congress an appropriation of $800,000 for the conversion of 1,600 of the additional guns on hand at the same price, viz, $500 per gun.

603. But if either of such guns should burst during the trial and proof of rapid firing during the progress of the second part of the experimental operations, then the Secretary of War may cause the further progress of experimental operations to cease before proceeding to the third part of the experiments, and no further expense against the War Department shall be incurred.

604. But if the first, second, and third parts of the experimental operations should all prove successful as showing the stipulated power and endurance of the various guns, and if the third part of the experiments shall show that the long-bored breech-loading gun converted from 15-inch smooth-bores shall prove to have power to penetrate 25 inches of iron or more, and if the long-bored breech-loader converted from a 10-inch smooth-bore shall prove to have power to penetrate 20 inches of iron of the target, then in that case the fourth part of the experiments shall be proceeded with on the terms proposed.

605. All the practical operations connected with the experiments, from first to last, are to be conducted openly on the Potomac River, or its banks, near Washington, as at first proposed, and under the observation of such officers as the Secretaries of War and the Navy may detail to be present, witness the experiments, and record the results. But "it is stipulated that such officers" "are not to interfere with the experimentor

not even by advice." He is to be responsible to the Secretary of War alone.

Respectfully, your obedient servant,

NORMAN WIARD.

606. Mr. Wiard submitted, as explaining why the Getty Board did not report in his favor, the following letter:

[Copy.]

312 SIXTH STREET NORTHWEST, WASHINGTON,
July 12, 1881.

Hon. ROBERT T. LINCOLN,
Secretary of War:

607. SIR: Your letter of the 11th instant, in which you advise me that "you conceive it to be your duty to cause to be laid before the Board all the information in your power to enable it to perform the duties imposed upon it by the act approved March 3, 1881," was duly received, and in reply I have the honor to state more at length than heretofore the considerations which induced me to make the request contained in my letter of the 28th ultimo.

608. I am at this time unable fully to understand what particular information may be gathered from my proposal to furnish armament under an appropriation now available, which can be considered germane to the subject of the duties of a Board whose report is not to have weight or force till it has been considered by Congress at its next session. It would rather seem to be an unfair mode of smothering a proposal which interferes with the interests of official inventors and their assignees.

609. It was the evident intention of the subcommittee which framed the law, by providing for the "selection" of a Board "by the President," to secure a disinterested tribunal composed of officers not interested directly or indirectly in patents or inventions, nor the associates of official inventors.

610. But the Board—including official inventors—selected "by command" of "General Sherman," in "General Orders" issued from "Headquarters" of "the Army," has a certain air of martial law about it not assuring to citizens of a republic in time of profound peace, and it smacks of uncivil and arbitrary usurpation of functions not delegated to soldiers except in time of war.

611. I have heretofore had the honor to place in your hands a copy of the printed testimony taken before the Senate Subcommitee on Appropriations on the subject of the malign influence exercised over projects for producing ordnance—shown by the fact that many officers occupying controlling positions in the service, such as "President of the Ordnance Board," "Constructor of Ordnance," "Members of Ordnance Boards," or officers of the staff of the Army, were the assignors, possessors, or interested advocates of inventions or patents connected with ordnance and their duties; and now in connection with the selection of the present Board and the reference of my inventions to it, I ask your personal attention to the pages, detached from the report of the Chief of Ordnance for 1873, and hereto attached, viz, the pages from 445 to 448, and twelve sheets of photolithographic drawings forming part of the same [these pages are not attached to this copy, it being deemed sufficient to introduce a few quotations without the illustrations in the body of this copy of this letter], being a report of the proceedings of a Board appointed by order of the Secretary of War to examine and report upon depressing and other carriages for heavy ordnance.

612. Fifty-eight projects were laid before the Board, as can be seen by the list following (from page 457, as above). Of these, forty-one are the inventions of officers of the staff corps of the Army:

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613. The Board have carefully examined and considered the plans, drawings, models, and papers submitted to it bearing upon the following devices, viz:

1	Depressing carriage for 20″ gun, to be operated by steam.	Lieut. W. S. Smoot, Ordnance Departm't.
2	System of operating heavy ordnance by steam-power	Do.
3	Compression for absorbing recoil of 20″ gun	Do.
4	Compressor for absorbing recoil of 15″ gun	Do.
5	Gun-carriage, muzzle-pivoting	M. Wappich.
6	Method of loading and maneuvering heavy guns	Lieut. J. A. Kress, Ordnance Department.
7	Traversing heavy sea-coast guns by steam-power	Do.
8	Counterpoise gun-carriage	Lieut. J. G. Butler, Ordnance Department.
9	Counterpoise gun-carriage	Do.
10	Apparatus for maneuvering heavy guns	Maj. J. G. Benton, Ordnance Department.
11	Service 15″ barbette carriage increased in height with two air-cylinders, front pintle.	Ordnance Department.
12	Service 15″ barbette carriage, center pintle altered for two air-cylinders.	Do.
13	Counterpoise platform for heavy guns	A. T. Brewer.
14	Telescopic rammer	Do.
15	Rotary gun carriage	Lieut. G. K. Dakin, Third Artillery.
16	Steam gun-carriage	James B. Eads.
17	Pneumatic depressing carriage (2 models)	Do.
18	Depressing gun carriage, to be operated by gun-cotton.	Lieut. Col. T. T. S. Laidley, Ordnance Department.
19	Vertical revolving battery	John Ridgway.
20	Revolving iron fort and pneumatic carriage	James T. Ryan.
21	Loading-house for 15″ gun	Lieut. Col. T. J. Rodman, Ordnance Department.
22	Counterpoise gun-carriage	Capt. A. R. Buffington, Ordnance Dep't.
23	Counterpoise gun-carriage	Lieut. A. L. Varney, Ordnance Dep't.
24	Depressing gun-carriage	(Nuttall's), submitted by M. D. Lawrence
25	Depressing gun-carriage	Mr. Albertson.
26	Depressing gun-carriage	Capt. W. R. King, Engineer Corps.
27	15″ barbette carriage, front pintle and center pintle.	Ordnance Department.
28	Apparatus for maneuvering and loading heavy guns	Henry Caudwell.
29	Kelso gun-carriage	J. R. Kelso.
30	Hydraulic buffers used in England for checking recoil	Letter referred by Gen. A. A. Humphreys Chief of Eng'rs, to Chief of Ordnance.
31	Device for checking recoil of heavy guns	Capt. J. Wall Wilson, U. S. R. M.
32	Device for lessening shock of discharge	Mr. Timby.
33	Depressing gun-carriage	Col. J. G. Barnard, Engineer Corps.
34	King's volume on counterpoise gun-carriages, published by Engineer Corps.	
35	Earthen battery and truck	Major D. C. Houston, Engineer Corps.
36	Iron fort with depressing carriage	Col. Serrell.
37	Counterpoise muzzle-pivoting gun-sling	Capt. W. R. King, Engineer Corps.
38	Casemate-carriage, without tongue, for 10″ Rodman gun.	Do.
39	Casemate-carriage, without tongue	Major D. C. Houston, Engineer Corps.
40	Casemate-carriage, without tongue, 10″	Major Q. A. Gillmore, Engineer Corps.
41	Apparatus for checking recoil	Col. Henry Brewerton, Engineer Corps.
42	Mortar-bed for heavy mortars	Capt. W. R. King, Engineer Corps.
43–55	Thirteen projects for depressing gun-carriages for 15″ gun.	Lieut. Col. J. G. Foster, Engineer Corps.
56	Cyclophoretic gun-carriage	Do.
57	Depressing carriage	Major C. B. Reese, Engineer Corps.
58	Atkins's apparatus for loading without a rammer	(Atkins), per Judge C. Mason.
	(Wappich's carriage and Captain W. R. King's carriage. The papers in these two cases were received from both Departments—Engineer and Ordnance.)	

614. From the foregoing the Board has decided to recommend for trial, in accordance with the resolutions contained in the body of the proceedings, the following projects, viz:

615. Benton's apparatus for maneuvering heavy guns; Maj. J. G. Benton, United States Ordnance.

616. Counterpoise gun-carriage; devised by Capt. A. R. Buffington, United States Ordnance.

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617. Among the plans approved and recommended for trial or service by the Board are the projects of Colonel J. G. Benton, Ordnance Department, and of Maj. A. R. Buffington, Ordnance Department, and these

are the two ordnance officers of the mixed board of five, selected by command of General Sherman, to which, you inform me, it is your duty to refer my proposal. How many more official inventors may be on the Board I do not know and have not time to inquire. A principal feature of my proposal is to furnish automatic carriages capable of being operated by a greatly reduced number of men and affording facility for firing much more rapidly than has heretofore been deemed possible.

618. The important features of my carriage are referred to in marked paragraphs on pages 10, 11, and 12 of the printed letter addressed by me to the Senate Subcommittee on Appropriations, having charge of the fortifications bill last session.

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619. (The printed pages referred to are introduced in this copy for the information of the Select Committee on Ordnance of the Senate, a copy had been previously sent to the Secretary of War:)

620. Heretofore only one condition affecting the value of an armament composed of a limited number of guns mounted in a fort has been considered indispensable for defense, viz, the power of the guns to penetrate the greatest possible thickness of iron armor protecting the sides of the ships of the enemy by which we may be assailed, and our ordnance authorities seem to contemplate making up for the acknowledged *slowness of fire or slow repetition by each gun*, by the number of guns estimated for, and for which emplacements have been provided by the engineers. *Undoubtedly the gun which could deliver five equally effective shots in the same time another one delivers one, would be five times as effective in battle as its slower competitor.*

621. The 15-inch long-bored breech-loading gun, referred to in the proposal printed with the t stimony taken by the committee, is intended to fire five shots while the "improved breech-loading 12-inch rifles of Colonel Crispin" delivers one!

622. It can be seen that my gun is devised to reduce the friction of the projectile as it passes out of the bore as much as possible, and I do not doubt can be fired five shots with its mechanical fit projectile without heating the gun as much as *one* shot with the Crispin gun, using an expanding projectile, would heat his gun, so that my gun would have no greater tendency to burst from "unequal expansion of its metal," when firing so rapidly, than the Crispin gun would have when firing at its slower rate.

623. My carriage (shown by drawings which accompany my proposal) is specially devised to secure facility for rapid repetition of shots. By its operation, *the gun is run forward again* to the position in which, being a breech-loader, its charge is inserted, and at which it is fired again, automatically, and *in the same time* required by the Crispin gun *to complete its recoil*. The heavy Crispin gun then requires the utmost effort of fifteen or twenty men to run it forward to its proper position for loading, by which much time is wasted. The operation of loading the gun cannot begin until this laborious process of running the gun forward has been completed, thus but one-fifth of the number of guns are required and but one-fourth of the number of men for each of the reduced number of guns.

624. Now, therefore, if it is true, as it seems to have been proven to the committee and assented to by General Benét, that we can, by improving the form, density, and size of the grains of powder so as to adapt it to the strength of the material of which the gun is made so that the gun will not burst, "*even if made of cast iron*," by the force of the direct pressure of the powder, securing, at the same time, higher velocity to the projectile; and if we can, by reducing the friction of the projectile by making it slide smoothly out of the guns so that we reduce the rate of heating to less than one-fifth, why can we not fire five shots by the new method while one can be delivered after the old time-honored mode? If we can fire five times as many shots in an hour by the new appliances, the new gun and new projectile, and produce the new guns of double the power for one-fifth the price of the other, procurable, too, in the one-hundredth part of the time, why should we buy five of the less effective guns instead of one of the cheaper ones—guns such as we can get so much quicker, also?

625. In other words, why should the United States purchase 2,200 new guns at $46,000 each, with 100 expensive projectiles and a carriage for each, besides converting 1,600 guns on hand expensively to make up the 4,000 reported as required, at a cost of $157,741,950, when we can, by converting the 1,600 guns on hand, according to the new plan, procure more effective armament, all complete, for $22,000,000, including—

300 15-inch long-bored breech-loading combined rifle and smooth-bore guns, with a carriage of the improved automatic kind, described and shown by the drawings, for each gun.

30,000 spiral triangular subcaliber centered mechanical fit projectiles of chilled iron (1,000 pounds weight each).

30,000 spherical shells, or so many as to make up that number if there be not so many on hand.

1,000 10-inch long-bored breech-loaders combined rifle and smooth guns, with a carriage of the improved automatic kind, described and shown by the drawings for each gun.

50,000 spiral triangular subcaliber centered mechanical fit chilled iron projectiles of 500 pounds weight each.

50,000 spherical shells, or so many as to make up that number if there be not so many on hand.

626. To the above-enumerated guns, 300 more can be added by converting the Parrott rifles and 8-inch guns on hand, and supplying for each gun 50 spiral triangular projectiles and 50 spherical shells for each gun, thus making up an armament far more powerful and effective than the one made up of 4,000 guns, as contemplated and recommended by the ordnance authorities.

627. It is confidently believed that the 15-inch gun in the proposal and specification referred to can penetrate 30 inches of iron at 1 mile range, if constructed according to the plan described; and if at the first trial they should not, it is almost certain that by further increase in the length of the bore (in a manner that is obvious), and by further increasing the size and density of the powder grains (which it is also obvious can be done), the necessary power can be secured without additional strain upon the gun.

628. That the 15-inch gun can be fired as rapidly as one round every two minutes for fifteen consecutive rounds, which rate of rapidity is five times as great as the Crispin 12-inch breech-loading rifle can be fired, and that it can penetrate twice the thickness of iron at one mile range, is not to be doubted.

629. It is believed that it is not possible to operate a gun of the necessary length and capacity of bore to give so high a velocity and such great power if mounted in the ordinary manner—to be elevated and depressed by turning on its trunnions. The recoil would be on a different plane from the plane of the bore. The recoil of my gun on its improved carriage is in the direction which coincides with the plane of the bore. A much smaller port-hole, or opening for the muzzle to protrude through, is, therefore, required for my gun than for any other in use in the United States, or in any other service. Therefore, I do not fear competition with the Crispin gun in any possible modification, such as increase of length; while to my gun there is no practical limit to the length to which I may extend the bore by lengthening the chase except the length to which it would give no advantage in utilizing the expansion of the gases of slower burning powder.

630. Besides, my projectile has a *subcaliber* puncturing point and body, and makes its hole through the target only of one-half the area of cross-section of the bore of the gun, and has the very best form of point for penetration. For these reasons, if I could offer no other, I would, even from a theoretical point of view, be justified in claiming double the work of penetration with the same caliber of gun; or, to state it more correctly, the same penetration with half the charge of the same kind of powder.

631. My best 10-inch rifle, converted from a 10-inch smooth-bore Rodman will, it is believed, penetrate through 22 inches of iron at 1 mile range; and, it is believed, prove capable of delivering 30 consecutive shots in 30 consecutive minutes, which *is five times as rapidly as any other gun in the world can deliver* 500, *pound projectiles*. It will have all the advantages claimed for the 15-inch gun within its sphere, and thus, by the adoption of this plan of converting 1,300 guns of those on hand of the two calibers, the Government will be put in possession of an armament capable of delivering 19,500 *tons of projectiles an hour*, while the Ordnance Department armament of 4,000 guns, at the rate of rapidity of fire attributed to the guns, *can deliver but* 5,675 *tons of projectiles per hour*.

Very respectfully, &c.,

NORMAN WIARD.

To the SUBCOMMITTEE ON APPROPRIATIONS,
In charge of the Fortification bill, United States Senate.

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632. I am sure, sir, that after receiving this information with regard to the character of the Board, that you will not consider me captious if I again earnestly ask you to revoke your decision as to referring my proposal to a board so selected and constituted.

633. Further, it could not be expected that the report of a board so constituted and selected, with such seeming disregard for the text and true intent and meaning of the law, such marked disrespect for the president particularly designated to "select the board," and for the com-

mittee which framed the law, could have much weight when it hereafter comes to be considered by the same Senators who carried the measure through for the express purpose of defeating the machinations of unscrupulous official inventors, their co-conspirators, assignees, and associates.

634. There was but two modes of constructing and converting guns laid before the Senate committee which secured the passage of the law (Public No. 69) of last session, viz, methods which involved lining the guns with a coiled, welded wrought-iron or steel tube and adapting them by the mode rifling to projectiles with a sabot less hard than the body of the projectile with a view to its expanding into the grooves of the gun or being squeezed through the bore while expanded or pressed into the grooves with great force to give the necessary rotation to the shot, and guns rifled without lining by cutting the grooves "right in the gun itself" with such form of grooves as to make the gun a combined rifle and smooth-bore adapted to the utilization of centered spherical projectiles, and to centered mechanical fit subcaliber projectiles with improved form of point for penetration.

635. It was shown to the Senate subcommittee that all the guns constructed or converted under direction of the Ordnance Bureau, from 1872 to the present time, were lined guns, including the Thompson, Sutliffe, Woodbridge, and Crispin guns. Vast sums of money had been expended under direction of the Ordnance Bureau in producing these guns from 1872 to the present time, yet not a single gun of 12-inch caliber or larger had yet been submitted to extreme proof in this country without being burst or disabled before a reasonable and satisfactory test had been accomplished. In fact no lined rifle gun of large caliber, using expanding projectiles, has ever been fired rapidly for thirty consecutive rounds without bursting, and even if fired slowly, the steady enlargement of the bore at the seat of the shot, from the first shot to the last, in every case of recorded trial, shows that lined guns are steadily and certainly progressing toward their own destruction, so that this mode of construction has come to be known in England as the "suicidal system." It was shown to the committee that lined guns had been universally condemned throughout the world previous to the attempt to make them in this country, and that both the Chief of Ordnance and Colonel Crispin, "the patentee," "president of the Ordnance Board" and "constructor of ordnance," had condemned them.

636. The Chief of Ordnance informed the committee that it was not intended to test the guns (the improved Crispin patent 12-inch breech-loading rifled guns) now being constructed by the Ordnance Department under the appropriation of 1880, and thereupon the committee, after being shown that the guns were utterly useless, struck out the appropriation from the House bill and inserted the clause in the act (public 69) providing for a disinterested board—

637. To examine certain inventions [viz, those laid before them], including the guns now being constructed or converted under the direction of the Ordnance Bureau.

638. The Board is to examine and report what [of these] are worthy of trial and the estimated cost of such test. This report will eventually be laid before Congress, and will then receive proper consideration.

639. By this action of the committee, as embodied in the law, all lined guns, and the Crispin guns as constructed and converted, are without provision of law for their further production, and even those contracted for in 1880, being relegated to the examination of a board whose report may determine that they are not worthy of test, may never be received into service, and the contract may, according to law, at the discretion of the

President, be annulled so as to cover the unexpended part of their contract price back into the Treasury.

640. There is, therefore, no other way to comply with the true intent and meaning of the law than to expend the appropriation in the act (Public No. 69) by giving the contract to me according to the terms of my proposal, which was prepared by me in strict compliance with the terms of the appropriation.

641. You will remember that Mr. Allison said (see page 4 of my printed letter addressed to you and dated 20th of May, 1881):

642. The War Department under this bill can make these experiments. *They can*, if they choose, *do just what Mr. Wiard has projected*, or if they cannot, I want to know the reason why they cannot, or what further legislation is necessary. If they can and will not, then it becomes necessary for us to provide in this bill a compulsory process.

643. I have, therefore, no intention of withdrawing my proposal. It is a *bona fide* one. I have, while I hope to have your personal attention to its terms, no objection to its taking the usual course, except that I could not expect justice to the government any more than to myself if it should be referred to a board composed wholly or in part of officers of the Ordnance Corps (all inimical to me solely because I have discovered and exposed their corrupt practices), who are themselves inventors or the associates of official inventors. I want justice, and this time I intend to have it, or, as Mr. Allison said, "I want to know the reason why."

644. With Mr. Beck I protest against a ring inside any bureau of this government running its own patents and injuring the chance of the government to get the best gun because its officers are seeking to forward inventions of their own.

I am, sir, very respectfully, your obedient servant,

NORMAN WIARD.

Communication of Norman Wiard.

645. The following was received from Norman Wiard and submitted to the committee:

ON IMPORTANT IMPROVEMENTS IN GUNPOWDER, CENTERED ANTI-FRICTION PROJECTILES, CANNON MATURED BY AGE, AND ANNEALED BY YEARS OF EXPOSURE TO THE MOLIFYING INFLUENCE OF THE ELEMENTS.

312 SIXTH STREET,
Washington, January 12, 1883.

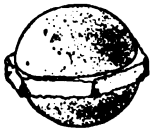
Senators of Select Committee on Ordnance:

646. The results of the Nut Island experiments were obtained with gunpowder very severe upon the guns, and which did not afford a corresponding velocity to the projectiles, and although the results obtained have never been equaled by any other experimentor, as was shown by the review I had the honor to read and lay before the committee, I desire you to understand that I have made additional improvements in gunpowder, in the guns, the method of rifling, and in my projectiles, which will enable me, whenever I have an opportunity afforded me, to as far excel the best results previously obtained; as the lenticular or mitten shot excelled the old time-honored spherical one. While the guns will be improved as smooth-bores for the use of spherical shells, ricochet practice, and for rapid firing as rifles, as well as smooth-bores.

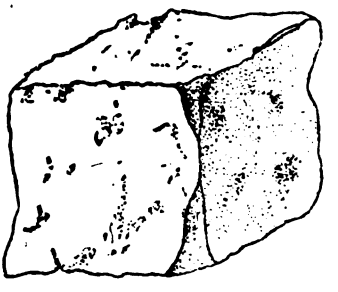
GUN-POWDER. U.S.

FORMS AND SIZES OF GRAIN.

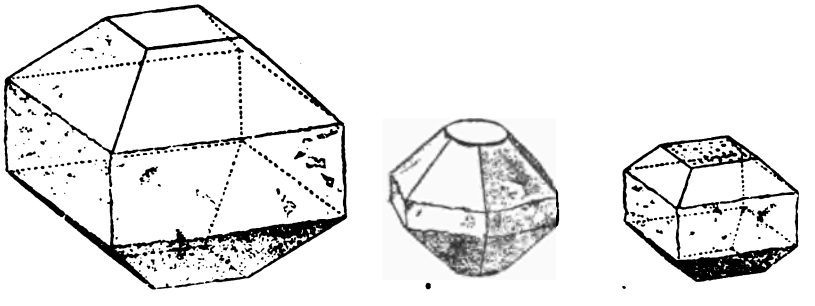
MAMMOTH.



SPHERICAL.



CUBICAL.



HEXAGONAL.

Thus according to my proposals, by an economical and ready method enabling me to convert all the obsolete guns on hand into combined rifle and smooth-bores, fully sufficient for the national defense in the present and near future; leaving nothing to be desired.

647. First, as to the powder.

648. Gunpowder composed of niter, charcoal, and sulphur intimately incorporated and properly prepared, when ignited, burns in a closed space and developes a large volume of gas, the expansive force of which can be utilized in cannon for the projection of missiles of various kinds to a comparatively great distance, and with great force.

649. It contains within itself the combustible and the promotor of combustion; the elements of carbon, and equivalents of oxygen; and althouh its combustion is comparatively quick, the time required for its total combustion can be divided into historical periods. It is not instantaneously consumed. There is a beginning, a middle, and an end of the operation.

650. From the beginning of its use in cannon and other engines of war, it has been prepared in grains larger or smaller, and these of greater or less densities, and a better regulated rate of combustion more or lessquick has been secured thereby.

651. The cuts show some of the sizes and forms of grains used in modern guns of larger caliber, and while great results have been anticipated from increase of the size and density of grain, the fond hope has not been realized to the extent of utilizing cast iron for rifled guns of large caliber, except in so far as I have accomplished it, principally because ordnance authorities have adhered to suicidal systems of rifling, and to expanding, wedging, jamming, squeezing, or balloting projectiles, all in the interest of official inventors, their associates and designers comprising the ordnance ring; and my success with the Nut Island experiments was due more to the centering the projectiles in the bore of the gun, with windage all around alike, than to any other feature of my inventions.

652. The invention, so called, of large-grained and dense gunpowder is generally attributed to General Rodman, date 1861. But I find in the Navy Ordnance Instructions, approved by the then Secretary of the Navy, the Hon. Will. A. Graham, July 2, 1852, Capt. C. Morris being Chief of the Ordnance Bureau, the following on pages 112 and 113:

653. In general, gunpowder of small grain and low specific gravity gives the highest range in the eprouvette, whilst recent experiments with the ballistic pendulum haves hown that the greatest initial velocity in a shot from a heavy gun is produced by powder of great specific gravity and of coarse grain.

654. At the time the Navy adopted large-grained and dense gunpowder, Captain, the late General, Rodman was engaged with the experiments upon which the Rodman plan of casting guns hollow and cooling them from the interior was afterwards adopted by the War Department, [1859,] John B. Floyd, Secretary of War.

655. Captain Rodman had great confidence in the strength of his system, but the use of fine-grained powder "burning from all its surfaces and developing seven-eighths of its gas during the first half of the time required for its total combustion" was "too much," not only for the solid-cast guns but for the hollow-cast ones also, and at the end of the fifth experimental year, when ten guns had been cast and proved, nine had burst. Only one of the guns had escaped destruction by the severe combined action of quick-burning powder and *uncentered* shot.

656. In England, the use of quick-burning powder, designated by French artillerists as *poudre brutale*, continued up to 1869, when some experiments were conducted with delicate instruments devised for the occasion, which showed that 30 pounds of R. L. G. (rifle large grain not the finest powder by far) in an 8-inch gun and with a projectile of 180 pounds, the pressure being 29.8 tons at the start, was reduced to 29 tons when the shot had moved forward only one-fourth of one inch. When it had moved one full inch the pressure was reduced to 18 tons per square inch; at 8 inches it was reduced to 12.1 tons.

657. Captain Rodman used even finer powder than that above referred to in his experiments, and he says, page 14 of his reports, referring to the firing with the 10-inch gun cast on the Rodman plan, which burst at the 315th fire—

658. "The shot recovered after the 214th fire was found cracked and marked by a smooth bright band on opposite sides, indicating that it had rubbed hard against the bore of the gun."

659. And on page 15 was found the first reference to the size of grains of gunpowder by that distinguished officer. He says—four years after the Navy had adopted coarse-grained dense powder—

660. "The powder used in these experiments was made by the Messrs. Dupont, was rather fine grained for cannon powder. * * * It was new, and is believed to have been a very quick, and therefore severe, powder upon the gun. * * * This powder is unquestionably too quick for guns of large caliber; nor is it believed that the increase in velocity and range at all compensates for the heavy strain to which the gun is subjected."

661. And on page 55 of the Rodman reports we have further confirmation of the fact that the Navy was further advanced in knowledge in relation to gunpowder than the Army Ordnance Corps, Captain Rodman says—

662. "We do not *know* the maximum *statical* pressure due to a given weight of powder and shot, nor how much the rate of combustion of the charge, or rate of application of the force, causes the bursting tendency to exceed that due to the *statical* pressure."

663. And this, notwithstanding the fact that Colonel Bomford had previously determined the maximum pressure, by drilling holes through the wall of a large gun at intervals along its length. Into these he inserted musket barrels, and from these bullets were fired into the ballistic pendulum, and from their relative velocity he deduced the maximum pressure at various points along the bore of the gun.

664. Captain Rodman continues:

665. "We do not *know* the difference in endurance due to a given difference in bursting tendency at each discharge, nor what weight of projectile is equivalent in bursting tendency to a given weight of powder, nor the difference in endurance due to a given difference in the thickness of metal."

666. "We do not *know* the difference in bursting tendency due to a given difference in temperature of the same charge of powder at the moment of ignition."

667. "Nor do we *know* the proper constitution of charge in order to produce a given velocity of projectile with the minimum bursting tendency upon the gun."

668. "And it is believed that the true interests of the country would be promoted, in a military point of view, by entering, at as early a period as practicable, upon a series of experiments, which would supply positive knowledge in place of probability in some and positive ignorance in *many other* points of the utmost importance to the national defense; for it is better that millions should be expended in time of peace and from an overflowing treasury than that a single gun should burst in action."

669. These are remarkable statements. After continuing experiments at the public expense from 1849 up to 1856 something ought to have been learned—even if he had to learn it from the Navy—and the proposition to begin another series of experiments to cost, may be, millions,

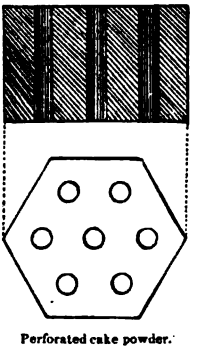
when such meager results had been achieved, was nothing more nor less than sublime impudence.

670. In 1874 General Benét made the following statement to a committee of Congress:

671. "Large-grain powder for heavy guns was first adopted by this department in 1861, at a time when other nations continued the use of small grain. This great improvement in the mode of manufacture was the result of careful study and experiment by the late General Rodman, who successfully used it in his first 15-inch gun. This, and his invention of the "perforated cake" powder, which has been adopted by and is now in use in both Russia and Germany, and the "pebble" powder, similar to our "mammouth," adopted by England, *created that revolution in the manufacture of gunpowder*, based upon purely scientific principles of combustion and evolution of gases, *that has enabled all nations to increase the size of their ordnance.*"

672. "The necessity for strength in any gun constructed dedends upon the amount of strain that is brought upon it, and this st rain is effected by the method and rate at which the gases are evolved in the burning of the powder charge and the rate at which the powder space behind the charge is enlarged by the gradual movement of the shot through the bore. It is evident that if, by any proper manipulation of the powder in manufacture, the size and form and density of grain can be so determined and adjusted as to confine the strain within certain limits, *the strength of the gun to resist such a strain need not reach the maximum requirements of steel, but may be found within the well-known capabilities of our best cast iron.*" (Testimony of General S. V. Benét, Chief of Ordnance, U. S. A., page 90, Rep. 384, H. R., Forty-third Congress, first seision.)

673. This is an impudent claim for invention. It has already been shown that Rodman did not invent, and was not even the first to propose, large-grained and dense powder, and neither large grains nor his "perforated cake" had anything to do with the increase in the size of ordnance abroad. All foreign powers have proceeded toward improvement in the size of ordnance, by selecting the strongest material in place of cast iron; and have adopted the strongest and most expensive methods of construction in order to provide as if by brute force to resist the enormous strains upon the projectile; and therefore upon the gun, of the quick-burning powder, powder burning "from all the surfaces"; powder which developed seven-eighths of its gas, in one-half the time required for its total combustion. No nation has adopted "perforated cake" ex-



Perforated cake powder.

cept for experiment. It has always given such erratic results, that the pressure it gave had to be deduced from a mean of a number of fires, and it has been concluded that the perforated cakes were blown apart with so much violence against the walls of the chamber and base of the shot, that as frequently as otherwise it was broken up into fine grains, and then its rate of combustion was as quick as the quickest, and neither Army nor Navy Ordnance Departments of the United States have ever adopted it, since the testing of the first 15-inch Rodman gun.

674. The following is what General Rodman himself said about large dense-grained powder in 1861 (see his reports, page 292):

675. The most favorable hypothesis that can be made with grained powder, is that the grains are spherical, and of uniform size."

"If, now, we suppose the powder to be so hard pressed that the gas cannot permeate the grains, and that the diameters of the grains undergo equal reductions in equal successive portions of time, we shall, at the end of half the time required for its total combustion, have consumed *seven-eighths* of the whole charge, the volumes of spheres being to each other as the cubes of their diameters, while the shot will have traversed only something more than *one-fourth* of the bore, supposing the time required for the combustion of the charge to = that required for the shot to traverse the entire length of bore."

676. "From which we see that with this kind of charge the gas is evolved in the inverse order of what itshould be; the evolution being greatest while the velocity of the shot is least, and least while that velocity is greatest, and giving rise to excessive pressure at and near the seat of the charge, and a too rapid diminution of pressure from that point forward."

677. "This highly objectionable property of grained powder may be remedied, in some degree, by increasing the size of grain, if it be sufficiently hard pressed to render it impermeable to gas under the pressure to which it is to be subjected in firing; for it is clear that the initial burning surface, the maximum pressure, the difference between the mean and maximum pressures, and the difference between the initial and the terminal burning surfaces, will all diminish as the diameter of grain increases."

678. "But to bring the maximum pressure within proper limits, requires such an increasein diameter of grain as to require either an inconveniently long gun or an increase of charge in order to produce the requisite velocities; since for a gun of ordinary length the grains would not be entirely consumed in the gun; and the larger the grain, the *more* of each would be blown out unburned. And in soft, lightly pressed powder, we lose all control over the rate of combustion, the larger grain sometimes giving the greater pressure, owing to the larger interstices causing a more rapid rate of inflammation."

679. No matter how much the size of grain and density of mass may be increased, the highly objectionable quality remains, of developing its gas most rapidly at first, and most slowly as the end of the operation approaches, giving intense and "highly objectionable" strain upon the gun at the instant of starting the projectile, and a too rapid diminution of the pressure afterwards; in fact, exerting its force in the best manner to enlarge, crack, or burst the chamber and bore of the gun, and distort, upset, wedge, jam, or break the projectile, and in the very worst mode to give highest velocity and force to the shot or shell.

680. All the efforts of inventors of guns during the past fifty years, or since rifled guns of large caliber have become a necessity to military "offense" and "defense," have seemingly been directed towards resisting the misdirected force of gunpowder instead of improving the powder itself. In the years between 1858 and 1864, the British Government alone expended $13,000,000 for the development of a new rifled breech-loading system—Armstrong's. Every one of the guns produced of larger caliber than a field gun were laid aside as useless at the end of the year 1863, and a new departure was made. Discarding breech-loaders, that government proceeded to rearm with still heavier calibers of rifled muzzle-loaders, built-up guns, using steel and wrought iron in combinations thought to give greater strength; but the uncertainty of endurance of the expensive new armament brought the authorities again to the conclusion that their latest adopted system was a failure, that it must be discarded, and that they must begin again *de novo*.

681. During the debate upon amendments to the naval appropriation bill at the end of last session, a Senator said:

682. I wish to call the attention of the Senate to one fact. In the siege of Alexandria the other day, which is said to have been one of the most remarkable of all the naval exploits in history in the particular of its being an engagement in which the heaviest missiles were thrown, and in the largest number, one of the British ships.

firing at *very slow time*, perhaps *not repeating its fire oftener than twenty minutes' interval was compelled to retire after one day's action* and go to an island in the Mediterranean Sea *for a new armament.* * * * *Every shot she expended cost the British Government a thousand dollars;* and *yet at the end of a single day of slow action that ship was compelled to retire* to an island in the Mediterranean, where they had reserves of artillery, *for a new armament. The result* will be shown when the report of this naval engagement at Alexandria comes to be made up by scientific men, as the actual facts as stated prove that *there is something, even among the English guns and German guns and French guns, which is still very imperfect, and which I trust very much will be supplied by American genius.*

683. *I have confidence in the capacity of our inventors to accomplish and master any improvement that needs to be mastered* for the success of our Navy in the future and for the defense of our coast.

684. A few days previously the Associated Press dispatches brought to us the following intelligence:

685. "LONDON, *July* 12.—The events of to-day at Alexandria have been comparatively unimportant. The bombardment was not general or long continued, and the truce negotiations were fruitless."

686. "The Times correspondent telegraphs from the fleet off Alexandria: "The Achilles and Temeraire will probably attack the Marabout fort and the Inflexible the Ras el Tin works to-morrow. *The Alexandra will probably have to go to Malta to get new guns.*"

687. If a new kind of powder made of the same constituents as that in common use in 1859, which would burn only from surfaces which would increase in area as the combustion progressed; so made that a differential regulatable rate of density could be imparted to it, being most dense at that part of the surface where the combustion begins, combined with any required reduced rate of density toward that part of the mass where the combustion terminates, it is evident that it would be be possible "to confine the strain within certain limits" and—

688. "The strength of the gun to resist such strain need not reach the maximum requirements of steel, but may be found within the well-known capabilities of our best cast iron."

THE IMPROVED POWDER.

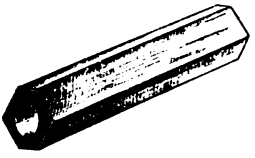
689. I have invented such a kind of powder, and machinery and appliances for its rapid production, of absolutely uniform quality, and, if necessary, it can be made by grinding up any of the various kinds of grained powder, such as are on hand, and reforming it to the new kind at low cost. In fact, I have already made and tested it on a small scale, and find that it gives more than double the power to the projectile, while the strain upon the gun is reduced more than one-half. It is an accelerating powder. It performs its work upon the projectiles exactly the same as gravity acts upon a falling body, overcoming its *vis inertia* slowly at first, and impelling it afterwards with an accelerated rate of velocity and force, exactly the condition required, and is the reverse of the conditions which control the rate of combustion with grained powder of such density as to prevent the hot gas from "permeating the grains" under the condiditions, which prevail in ejecting shot from cannon.

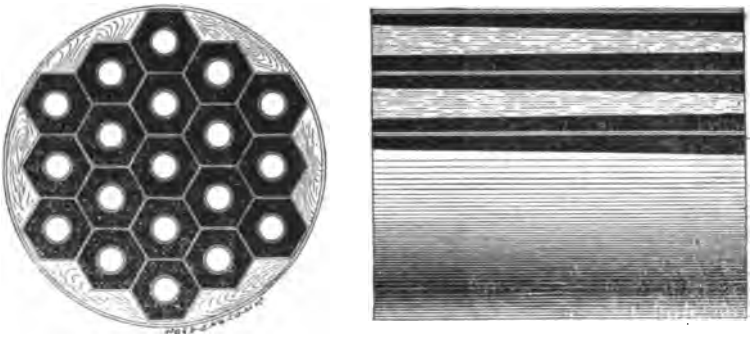
690. The above cut represents a cartridge, devised by me, made up of nineteen maybe more or less tubular prisms like Fig. 1.

691. Each of these prisms has a tapered hole through along the axis, and each is covered with an incombustible paper jacket, cemented upon all the outside surfaces except the front end, so as to confine the combustion to the interior and front end surfaces, thus securing steady increase of the area of surface undergoing combustion as the decomposition by burning and development of gas progresses.

692. It is obvious that if the powder composition should be as well incorporated as it is in grained powder, and of such uniform density

as to prevent the hot gas from permeating the mass, the steadily increasing area of surface undergoing combustion would cause the gas to be developed more slowly at first and more rapidly toward the last, which would alone perhaps be sufficient to accomplish the desirable end.





NORMAN WIARD'S IMPROVED CARTRIDGE FOR 15-INCH, CAST-IRON, "COMBINED RIFLE AND SMOOTH-BORE GUNS."

693. But if more is required, it is easy to secure any required difference of density between the surfaces upon which the combustion begins and those increased-in area ones, upon or at whichthe combustion terminates.

694. It is also obvious that if extremely mild action is required at the beginning—for the sake of the gun—that quality of force can be secured to any practical extent required, by reducing the area of combustion surface upon which the ignition begins, coupled with increase of density at that part; if necessary, making it as hard as the surface of a piece of anthracite coal, in combination with reduced density if necessity to the extent of artificial porosity in that part of the powder composition which burns last, so that it will be in that condition referred to by General Rodman—"soft, lightly pressed powder," in which "we lose all control over the rate of combustion," but under which, if we desire it with this improved cartridge, we are willing to let it have its own way, so that it follows up the rapidly escaping projectile to accelerate its headlong flight. [See cut, page 212, Figs. 14, 15, 16, 17, 22, 23.]

695. The appliances for forming the prisms with absolute uniformity of density, as well as regulating the differences of density described, have all been devised; but as patents are pending I prefer not to have anything relating to these and some modifications in forms and kinds of cartridges published at this time.

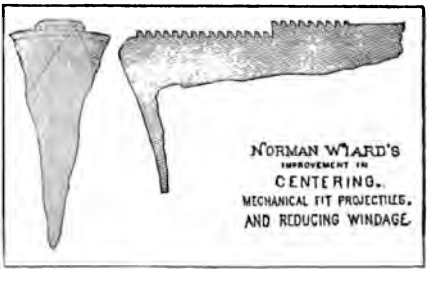
696. The cartridge I have described for a 15-inch cast-iron gun is, as to itsproportions of size, form, and differential densities, so far only theoretical or based upon reasoning alone. The exact conditions *can only* be determined by experiment.

697. If such powder as this had been available in connection with cen-

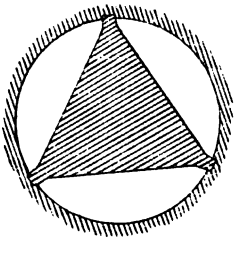
tered mechanically fitting projectiles to the English Government in 1859, the Armstrong system, upon which $13,000,000 was expended in three years, would never have been adopted; cast-iron guns costing 4½ cents a pound would have fully met every requirement up to this time and for all time to come; because, with such powder and such projectiles "*the strength of the gun to resist such a strain need not reach the maximum requirements of steel, but may be found within the well-known capabilities of our best cast iron.*" Since 1859 that government has expended $50,000,000 for large rifle guns, "built up" of the most expensive materials with costly workmanship. Nine-tenths of this expenditure would have been saved if the "*poudre brutale*" could have been replaced by such cartridges *as would develop one-eighth of its total volume of gas during the expenditure of the first half of the time required for its total combustion, and seven-eighths during the other half of the time*, or powder approaching that quality to a practical degree. By substituting cast-iron guns of far greater power, susceptible of being rapidly produced at one-tenth the cost,

MY IMPROVED PROJECTILES,

called "the spiral triangular, centered subcaliber mechanical fit projectile," with a "cutting point," is an improvement upon the "lenticular

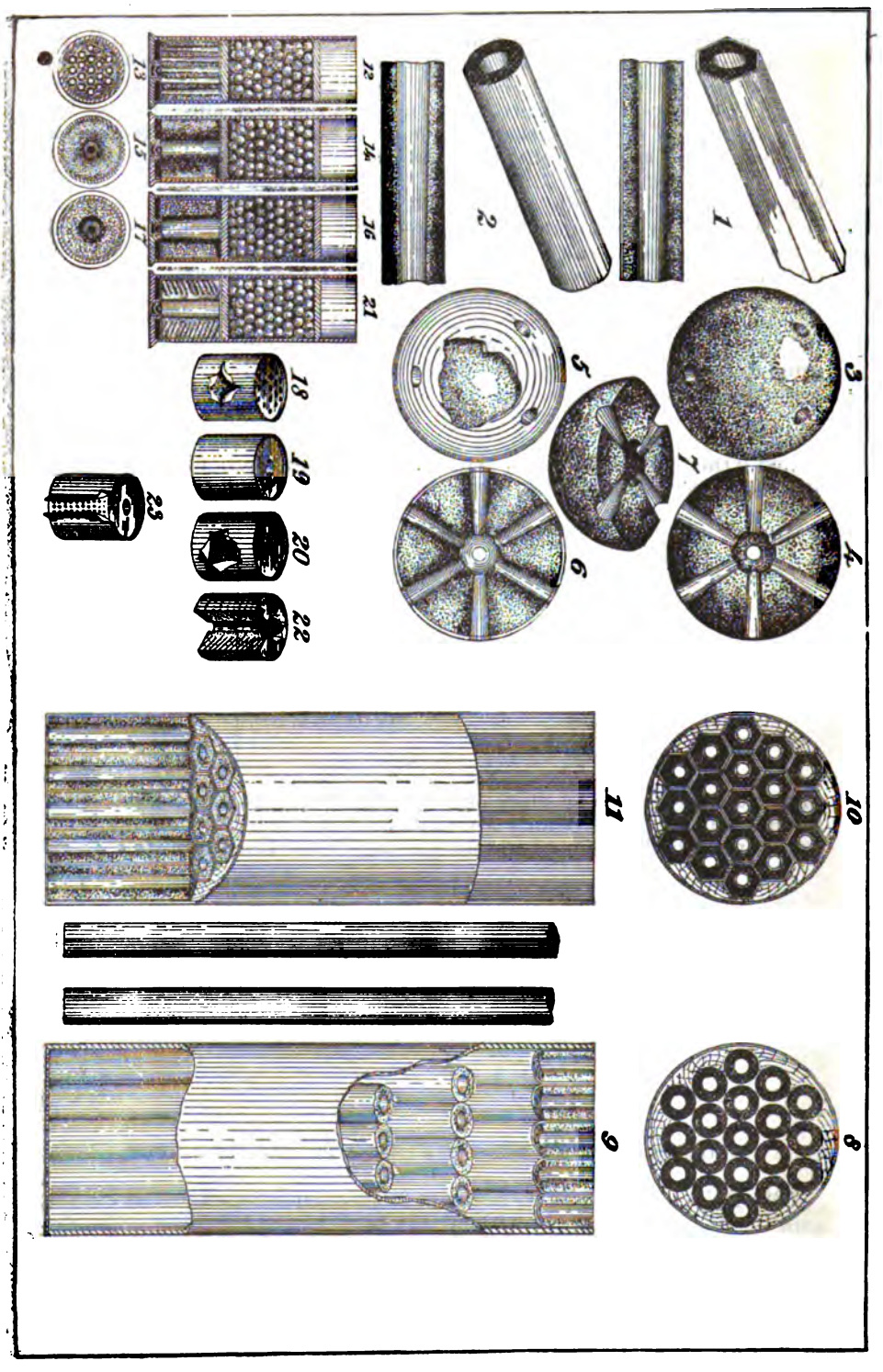


or mitten shot," used so successfully by me during the Nut Island experiments, the merits of which are explained in the review of those experiments I had the honor to read and lay before the committee.



CROSS-SECTION AT MID-LENGTH OF TRIANGULAR SHOT.

698. Being centered by its bearings in three equidistant grooves in the gun it slides out smoothly without any tendency to balloting. The devices shown on the drawings exhibited to the committee effectually prevent the escape of gas past the windage band, and the usual upsetting near the middle of its length does not reach that extent—within the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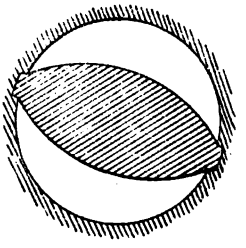
permanent elasticity of its metal—that permits it to come in contact with the surface of the bore at any part of its length, and, being so centered and supported in the gun, makes its exit without touching the surface of the bore, and thereupon with less frictional resistance than occurs to any other form of projectile, which means that all the force imparted to the shot by the expanding gases of the powder is stored up *and carried out of the gun* to be expended on the iron target or whatever it is aimed at.



CROSS-SECTION AT MID-LENGTH OF LENTICULAR SHOT.

699. The "lenticular or mitten-shot" [see cut, page 72], which was also a centered subcaliber mechanically fitting projectile with a cutting point—but adapted to two grooves instead of three—had the same antifrictional qualities. I made practical experiment with one of these, which weighed 535 pounds, during the Nut Island experiments to determine the exact value of its resistance in passing out of the gun in "foot pounds."

700. When the gun was laid horizontal, 68 pounds of force determined by a spring-balance was required to slide it into and out of the gun; moving the shot 12 feet, against this resistance, therefore, required 836 "foot pounds" of "work" to be expended upon it.

701. I drew the attention of the joint committee on ordnance of the Fortieth Congress to the laws relating to *the mechanical equivalent for heat*, as deduced from the experiments of Joule, and laid down in a "sketch of Thermodynamics," by Dr. P. G. Tait, M. A., and an extract was republished (pages 187, 188, Rep. Com. No. 266, Fortieth Congress, third session) from which I quote:

702. "1st. *The quantity of heat produced by the friction of bodies, whether solid or liquid, is always proportional to the quantity of work expended.*"

703. "2d. *The quantity of heat capable of increasing the temperature of a pound of water (weighed in vacuo, and taken at between* 55° *and* 60°) *by* 1° *Fahr., requires for its evolution the expenditure of a mechanical force represented by the fall of* 772 *pounds through the space of one foot;*" and

704. "3d. As no one has yet pretended to rival in accuracy the experiments of Joule above mentioned, and as his celebrated result of 1843, so very close to the truth, preceded all other recent sound attempts to determine the mechanical equivalent of heat, the results of *direct* methods since employed by other observers may be passed over with the remark that they agree more or less perfectly with those of Joule."

* * * * * * *

705. "The unit for measurement of work usually employed by British engineers is the foot-pound; and though this varies in amount from one locality to another, it is in such general use and so convenient when absolute accuracy is required that it will be employed throughout. It is the amount of work required to raise a pound a foot high. It is evident that to raise any mass to a given height the amount of work required is proportional to the number of pounds in the mass, and also to the number of feet through which it is to be raised. Thus, to raise a hundred feet a furlong high requires the same expenditure of work (73.920 foot-pounds) as to raise a stone-weight a mile high, or a pound 14 miles. And the potential energy of the raised mass, or the work which can be got out of it in virtue of its position, is precisely equivalent to the work which has been employed in raising it."

706. The 836 foot-pounds of resistance by friction produced by ejecting one of my centered mechanical fit projectiles, weighing 535 pounds, would, therefore, only be equal to raising the temperature of a pound of water one and one-fifth of one degree Fahr.—one and one-fifth of one unit of heat.

707. In May, 1864, Captain Fishbourne, R. N., stated to the Royal United Service Institution, London, that it required 40 tons of pressure to force an Armstrong lead-coated projectile of 25 pounds weight slowly through the bore of a breech-loading rifled gun of that caliber.

708. To move a projectile 12 feet against this resistance would, therefore, expend 960,000 foot-pounds of work, and would develop more than 1,200 units of heat.

709. One effect of retarding the projectile by this enormous resistance would be to give the powder more time to develop enormous pressure before the shot would be started.

710. This would also enormously increase the already high temperature in the gases which rise with the increase of tension, and, in turn, the higher temperature would rapidly hasten the rate of combustion, while the high temperature resulting from these combined phenomena would aid the friction in rapidly heating the interior of the gun.

711. The gun being heated from the interior, while the exterior remained at a lower temperature, would bring into play the bursting tendency resulting from unequal expansion of its metal.

712. Mr. Robt. Mallet, a high authority, refers to the effects of heat and unequal heating of guns from the interior, in his work on "The Construction of Artillery." I quote a part of his reference to the subject from the report of the joint committee on ordnance, Fortieth Congress, as follows:

[Effect of heat on guns, p. 186, Rep. Com. No. 266, Fortieth Congress, third session.]

"713. "SECTION 89. Applying Professor Hodgkinson's experimental results as to the extensibility of cast iron under strain to this reasoning, and taking the coefficient of expansion by heat for cast and wrought iron as the same for low temperatures (strictly as 1000893, 1000894 for temperatures under 212°), we have the extension for cast iron for the square inch of section equal about $\frac{1}{10000}$ of its length for each ton of load, up to seven or eight tons, at which its elasticity becomes permanently impaired; that is to say, when it begins to lose its form. An equal change of length is due to eight degrees of Fahrenheit difference in temperature."

714. "SECTION 90. Let us now assume a 64-pound shot rammed home at 2,000° Fahrenheit, which is under a white heat, and that it remains 50 seconds in the gun while the latter is being run out and fired; that in this interval the shot transmits $\frac{1}{10}$ of its heat to an equal mass of the cold gun, and that the whole of this is operative in expanding a cylindric ring of a determinate thickness around the ball, then we have

$$F = \frac{2000}{8} = 25 \text{ tons},$$

as the mean compressive strain per square inch upon this interior ring. But as the ultimate cohesion of cast iron does not exceed about eight tons to the square inch, the actual effect upon the strength of the gun is the same as if about three inches of its thickness were removed, or that an inch in thickness of its interior metal were removed, and a total strain of 17 tons were at the same time visited upon the remaining section of its thickness. At such a conjuncture, with such a steady strain already on its metal, the gun is fired and an additional impulsive strain, equal to the work done in giving to the shot its initial velocity, is suddenly brought upon its material."

"This, even with the regulation reduced charge for hot shot, of $\frac{3}{4}$ the service charge for cold shot, is seldom less than $2\frac{1}{2}$ tons on the square inch of section, producing from the impulsive nature of the force an extension equal to that of a passive strain of 5 tons. The wonder, then, is rather that any gun stands than that many should burst."

715. "SECTION 93. A train of effects, quite analogous to those described, are brought into operation in *very quick firing*, whether with hot or cold shot, when the interior of the gun, continually receiving fresh accessions of heat from the rapidly succeeding flashes of powder, is not given time to transmit it by conduction through its metal to the

exterior. The limit of the heat that could be conceived communicated from one discharge to the gun, would be the whole of that generated by the ignition of the charge. Assuming the formula for gunpowder to be K O, NO5+S+C3, its atomic weight will be 135, and one part by weight will include 0.1333 of carbon. Now, Andrews (Reports Brit. Assoc., 1849) found that one part of carbon evolves as much heat in burning as will raise an equal weight of water 7900° Cent. Hence, neglecting the sulphur as not oxidized in combustion, the heat generated by the firing of any charge of powder is sufficient to raise the temperature of an equal weight of water, 7900°×0.1333=1053° Cent.=1895.4 Fahrenheit, or to boil about nine times its own weight of water, or to heat about nineteen times (18.945 strictly) its weight 100° Fahrenheit."

716. "SECTION 95. In this case (that of heating by quick firing) the interior expansion is not almost limited, as in the former, to a ring in the immediate neighborhood of the shot, but extends to the whole length of the chase or bore, so that the whole gun becomes lengthened by the "end on" strain of its expanded interior."

717. Every proposal for large rifled guns made to committees of Congress, to the War or Navy Departments, the Ordnance Department, or the Ordnance Bureau, or emanating from ordnance bureaus—except those I have made—has contemplated the use of projectiles with a soft metal sabot or band, to be expanded or squeezed into the groves and forced through the bore, encountering such resistance by friction as that referred to by Captain Fishbourne, which, as has been seen, required 40 tons to push a small shot of 25 pounds slowly through the bore.

No gun of 6-inch caliber or larger, so rifled or shotted, breech or muzzle-loader, has ever, nor ever can, withstand 20 rounds fired consecutively as rapidly as is required in battle without bursting.

Millions of dollars have been expended in producing such guns, but as guns for service they are not worth as much as are their fragments after bursting would be as old iron.

I stated in evidence before the Senate subcommittee of appropriations January 7, 1881:

718. * * * "I am an inventor; I am enthusiastic about my art, and I do want to have so much recognition as to have the government, to which I have always been loyal, let me show how to save a hundred and fifty millions and how to arm the fortifications effectively, not only for the present, but on a plan that is commensurate for the future, and of reasonable cost." * * *

719. "Now, in testing guns, there is a quality of test that has never been applied in this country or in Europe. A large proportion of all the force that has a tendency to burst a gun comes from the unequal heating of the gun that results from friction of the projectile as it passes out of the bore in perhaps the two-hundredth part of a second. All the guns that have been heretofore made by our Ordnance Department, or nearly all of them, have been adapted to and supplied with a kind of projectile called "expanding projectiles" (patented by Capt. J. G. Butler, of the Ordance Corps). These projectiles are made with a body of cast iron or steel, and they have a soft-metal sabot about the base, and they are inserted into the gun just in front of the cartridge, a position called "the seat of the shot." Upon the ignition of the charge they receive the impact of the tremendous force, which has a tendency to drive the sabot forward, expanding it to fill the grooves of the gun, at the same time jamming it forward and squeezing it between the rigid body of the projectile and the surface of the bore. This has the effect to enlarge or stretch the bore of the gun at the seat of the shot, as all the tables of enlargement which accompany the reports of inspectors of guns show, and thus the bore of the gun becomes a tapered tube, of largest diameter at the position from which the shot starts, as it is being ejected from the gun by the tremendous force of the exploding charge of powder, and the bore being smaller toward the muzzle, the almost incompressible projectile has to be squeezed through the tapered tube in a fraction of a second of time. The result of the friction, in addition to the retardation of the projectile, detracting from its power, is the evolution of a large amount of heat, which, expanding the interior of the gun in advance of the heating of its exterior, is the principal cause of its bursting. Prof. F. A. P. Barnard, of Columbia College, in a letter he was kind enough to write me many years ago in relation to this subject, said: "There is no strength whatever which can possibly be given to a gun which the immense force arising from unequal expansion by heat will not be sufficient to overcome."

720. "It is evident that if the friction of one projectile passing out of the gun raises the temperature of the interior, if a sufficient interval should elapse it would return to

its normal temperature again in time. If two shots were fired in quick succession more heat would be communicated and retained in the interior of the gun than if only one was fired; and if a large number of rounds, 30 or 40, should be fired in quick succession, with the expanding projectiles, heat enough might be evolved to weld the shot to the metal of the gun or melt it. Not so, however, with the Wiard shot, called "mechanical fit" projectiles. These do not change their form in the gun or expand in the grooves, but pass out with the same diameter and form they have when inserted, as easily and freely, because the friction is no greater. Therefore, even if the bore should be enlarged in diameter at the seat of the shot, and tapered thereby, the effect would be to only make the shot fit more loosely in the gun at that part, and slide out along the rifle grooves more easily, without any tendency whatever to unequally heat or burst the gun. This is the principal feature of my system of rifling, and of the projectiles adapted to it; and knowing that expanding projectiles have a greater tendency to burst the gun under rapid firing, which my projectiles do not, I am anxious to see the two systems tested by firing the guns in competition, with equal rapidity, for at least thirty rounds. If that test proves to be one that either or both the guns cannot stand without bursting, it being the real test of battle, is it better to find it out now, before $140,000,000 are expended for a useless armament of the fortifications, or to wait until the gun is surrounded by patriotic soldiers or citizens in actual battle array, defending their homes against an invading foe? The expanding projectile and the system of rifling adopted for the Crispin patent guns are the most unmechanical devices that ever were conceived by any person in the world for a practical purpose."

721. "Senator ALLISON. Is that in use in this country and in Europe also?"

722. "Mr. WIARD. We have now no other projectile in this country that is officially adopted by the department."

723. In 1876 I concluded a series of experiments to determine the best

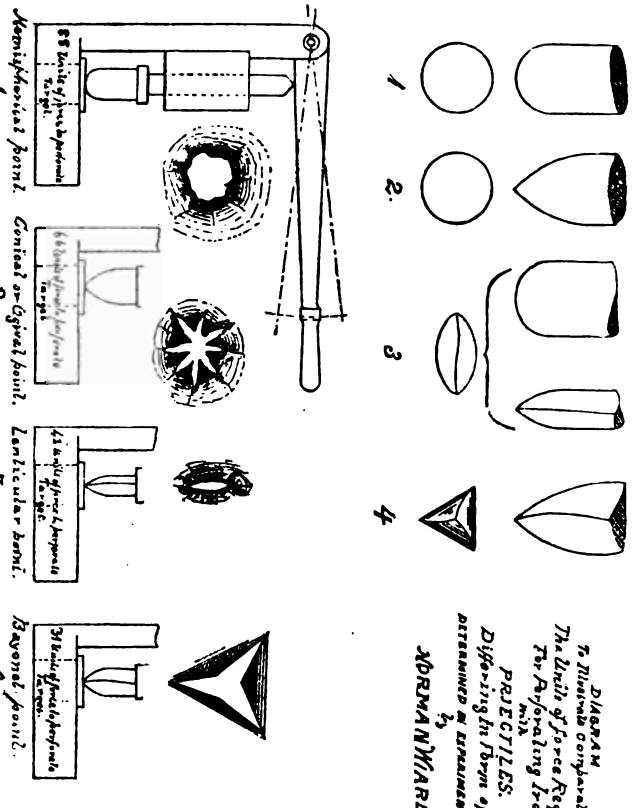


DIAGRAM
To illustrate comparatively
The Limit of force Required
For Perforating Iron
PROJECTILES.
Differing in form of Point.
DETERMINED BY EXPERIMENT
BY
NORMAN WIARD.

form of point to projectiles for the penetration of iron defenses. The diagram graphically shows the result.

724. The hemispherical-headed shot required 88 units of force to penetrate iron even of a thickness equal to the caliber of the gun. The conical or ogival pointed shot required 66 units; the lenticular or mitten shot form of point 42 units, and the triangular or bayonet point 31 units of force.

725. On account of the improved form of point in the triangular pointed shot, it was able to pierce iron with about two-thirds the force required for the lenticular or mitten shot form of point.

726. But this was not the only advantage resulting from the improvement in the form of point to the projectiles; in four cases out of ten the hemispherical-headed punch, made of cast iron, with which the experiments were made, broke in puncturing wrought iron of a thickness equal to its diameter.

727. The conical or ogival pointed shot broke in six cases out of ten in puncturing iron one and a quarter times as thick as its diameter.

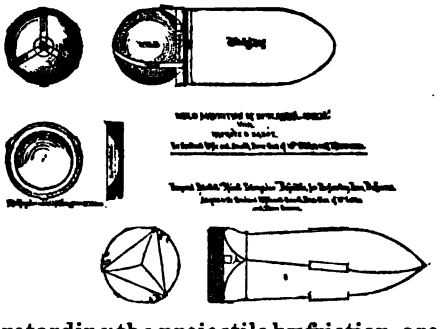
The lenticular punch broke once in ten times in puncturing iron one and a half times as thick as its diameter, while the triangular pointed shot only broke once in ten times in puncturing through a thickness twice its diameter; which shows that with this improved form of shot the work it is capable of performing is expended on the target and not internally or within itself, as was the case with all the others.

728. Shots made of this form and of steel tempered in oil can be forced through a greater thickness of iron defenses than any other that can be made.

729. A practical plan for making steel projectiles of this form cheaply has been devised.

730. A cylindrical shell, centered mechanically, fitting with the same windage band and the same twisted triangular form of point, has been designed to carry a large exploding charge for use against earth-works and unarmored ships. The body is slightly subcalibered to avoid the injurious effects which arise from the upsetting at the middle of the length of projectiles of this kind, and fixed ammunition of spherical shells have been devised, strapped to an improved sabot in such a manner that the straps, which are made of soft brass of slightly less thickness than the windage space, center the projectile in the bore of the gun, while projections on the wooden sabot fit into the grooves so as to guide the straps centrally on the lands midway between the grooves.

731. By these devices the injurious effects upon the gun and the shell, resulting from the upsetting of the shot indentation of the bore of the



gun, balloting and retarding the projectile by friction, are entirely avoided, while improved precision and higher velocity to the projectile are secured.

732. The following was elicited during my examination before the Senate subcommittee on appropriations, having charge of the fortification bill, 7th January, 1881:

733. "Senator ALLISON. Are these smooth-bore guns sufficiently strong to endure this rifling in the body of the gun?"

734. "Mr. WIARD. I have no doubt of it whatever. It is supposed that rifling weakens a gun greatly, but it is well known to persons in the habit of estimating the strength of cylinders subject to an elastic pressure from within that any tube closed at the ends and subjected to elastic pressure from within has twice the strength to resist transverse rupture that it has to resist longitudinal rupture. If it should burst it would naturally, by elastic pressure, split lengthwise. If the groove of the gun was lengthwise and parallel with the axis of the bore it would weaken it, but as it goes across the axis in a spiral around the outside it is nowhere any great distance lengthwise of the gun in the parallel of the axis to the bore; consequently, it affects the gun very little."

735. "Senator ALLISON. What is the virtue of your process of rifling—just what you have described?"

736. "Mr. WIARD. There formerly were two grooves. I now adopt three grooves. It is in centering the projectile in such a manner that the upsetting, when the force of the powder acts against it, only changes its form very slightly. If it is a sperical projectile, it shortens its axis, which coincides with the bore of the gun and increases its diameter. I have some photographs of it here. The fact is that in the old method by the upsetting of the shot, it is done in such a short space of time that it indents the bottom of the gun and does great injury to it, then rebounds and strikes the top, and it goes balloting up and down until it gets to the muzzle and escapes. I adopted the plan of supporting the projectile centrally in the bore, so that when the shot was inserted the body of the projectile did not touch the gun at all, and if there was any upsetting it was not near the surface of the bore, and if upset sufficiently to touch the bore it would touch it all around alike. The windage was exactly the same at the bottom as at the top."

737. "Senator ALLISON. Your system of rifling and your projectile must go hand in hand?"

738. "Mr. WIARD. Yes."

739. "Senator ALLISON. That is to say, you have invented a projectile which meets your system of rifling? The one must be a part of the other?"

740. "Mr. WIARD. It is a mechanical-fit projectile; that is, it fits into the rifle-grooves, and has the same form when it comes out that it had when it went in. It does not change its form in the gun. A projectile that does not permanently change its form in the gun creates no friction and does not jam in the bore. On the contrary, the expanding projectile is liable to wedge its sabot up between the rigid body of the projectile and the wall of the gun, and has a great tendency to burst it." (Sen. Mis. Doc. No. 44, Forty-seventh Congress, first session, p. 19.)

741. If such powder as I have described and such centered mechanical fit and centered spherical projectiles had been available for use by the government from 1859 to the present time, all the great cast-iron guns, rifled and smooth bore, including mortars and flank defense howitzers, purchased at a cost of from 9¾ to 25 cents a pound, could have been procured at a cost no greater than 6½ cents a pound, for that was the cost of such guns except for the Rodman royalty and the patent monopoly.

742. It would have been no more difficult to procure rifle guns of large caliber than smooth-bores, and not less than twenty millions would have been saved to the Treasury.

It is not too late to utilize these important inventions now, since all other schemes have failed; but if it is done at all it must be done at the suggestion of this committee.

743. The Getty Board has not recommended any change from expanding projectiles and "*poudre brutale*," and the Chief who commands a corps of sixty official inventors and owners of patents, on which the anticipated royalty amounts to three times as much as the total cost of arming the fortifications *de novo* on a practical plan, ought not to be expected to desire a change to another, even a better plan.

744. The owner of the Eureka projectile, in a communication to the

Senate subcommittee on appropriations in charge of the fortifications, said in a written communication published with the report:

[Letter of Mr. Arrick, pp. 79, 80, Mis. Doc. No. 44, Forty-seventh Congress, first session.]

745. "In the act approved May 4, 1880, for the fortifications and other works of defense a large appropriation was made for subjects, including projectiles, and in the fortification bill of the House now pending before the Appropriation Committee of the Senate, another large appropriation, including projectiles, is under consideration. It is evident that no other projectile is contemplated by the Ordnance Department except the officially patented ones, under these expenditures; nor is it probable that any other or better one will hereafter ever be purchased while all the expenditures for ordnance of every kind are subject to the control of a ring of official inventors and their assignees, the manufacturers of the guns and projectiles paying royalty to the officers of the Ordnance Corps."

746. "For the armament of the fortifications of the United States not less than 300,000 rifled projectiles are required. and the total cost to the government will be not less than $30,000,000, of which not less than $20,000,000 will be the gross profit."

747. "Such a magnificent sum should not be expended or disposed of by interested or irresponsible persons. Some guarantee should be required from those who have the disposition of the money, no matter how excellent the reputation of the agents of the government might be for integrity. The reputation of our Ordnance Corps has been frequently questioned. The commissioners on the purchase of arms, Messrs. Holt and Owen, in their report on case No. 103, Capt. T. J. Rodman, official inventor of the Ordnance Corps, and Charles Knapp, his assignee, and manufacturer of ordnance, said:—"

748. "As officers in charge of government establishments enjoy great advantages in maturing designs suggested by their current duties, they do not stand in fair competition as sellers of patent rights with those not having such advantages. If these valuable inventions thus made and matured are sold to citizens who may claim a degree of remuneration according to the government need of the invention, in the end the government pays more for such inventions than if made by others, and may thus be injured rather than benefited by the possession of such a class of ingenious officers."

749. "Article 1002" (of the Army Regulations) "forbids any officer or agent in the military service to purchase from any other person in the military service, or make any contract with any such person to furnish supplies or services, or make any purchase or contract in which such person shall be admitted to any share or to any benefit therefrom."

750. "The seventh of the conclusions of the Joint Committee on Ordnance of the Fortieth Congress, Report No. 260, Senate, third session, page 60, says:"

"That no officer of the Army or Navy should be allowed to receive a patent for any article required, or likely to be required, for use in those branches of the public service, or to be in any way interested in the manufacture or procurement of such articles. * *"

751. "8th. That the Ordnance Department of the Army can be entirely abolished with great advantage, as to economy, and without detriment to the good of the service. The duties now performed by the officers of that corps could be performed by officers detailed from the artillery service, under the direction of a chief stationed at Washington. In this manner the whole expense of the ordnance establishment would be saved, and artillery officers, who have not only scientific training, but practical experience, would have a voice in the selection of the guns and ammunition they are required to use."

752. "Senators, it is not to be believed that, with such statement of facts before you, Congress will continue to appropriate money for the armament of fortifications in large amounts, annually, if it is to be expended by a corps of official inventors for the promotion of their own pecuniary interests and without regard to the public interest. Some new system must be adopted or some new mode of controlling and directing the expenditures, which will secure the best and cheapest articles for the use of the government, else the Treasury will be swamped, and when we come to be assailed by a foreign enemy we will find that all the treasure that has been devoted to the preparation for the national defense has been wasted, and worse."

753. "Instead of complying with the earnest and oft-repeated request of the Chief of Ordnance for the amendment of the patent laws so as to legalize obtaining of patents by officers and agents of the government, and officers and members of ordnance boards, the criminal laws should be so amended as to enjoin upon district attorneys and grand juries the prosecution of offenders who take advantage of their official positions to impoverish their more honorable competitors and rob the Treasury. By the present system the genius of our inventors is discouraged, the prestige of the nation endangered, and the public enemies encouraged."

[Pages 27 and 28, Mis. Doc. 44, Forty-seventh Congress, first session.]

754. Senator BECK. Now, coming back to the money you are expending at this time the board adopted the patent of their president, as I understand you to say, and you are now constructing four guns of that patent?

755. General BENÉT. We are now constructing four on that system.

756. Senator BECK. What is his pecuniary interest in these guns? What is his patent worth to him in the construction of these four guns?

757. General BENÉT. *As far as I know it is not worth to him one cent.*

758. Senator BECK. Why did he get the patent, then?

759. General BENÉT. In the Army, as in other professions, we like to have the credit of whatever we do, and I expect that Colonel Crispin, who is considered a very ingenious man and a man of great ability, has, as Mr. Wiard has stated, invented a great many things and patented them.

760. Senator BECK. I see from the list laid before us that your ordnance officers have twenty-two or twenty-three different patents among them.

761. General BENÉT. Very likely; but I presume they are not for guns.

762. Senator BECK. Two officers have twenty-two patents.

763. General BENÉT. There may be more than that.

764. Senator BECK. You say that Colonel Crispin takes out a patent, pays the expense of doing it, and attends to it, all for nothing, charges the government nothing for it, and it does not increase the cost of the gun.

765. General BENÉT. With regard to the gun, *I do not believe* it increases the cost of the gun one dollar. *I am not aware* that there is one cent in regard to the matter at all.

766. Senator BECK. You think, therefore, that all these patents recommended by and presented before us as being owned by these Army officers are taken out purely for glory, without any compensation.

767. General BENÉT. No; I will not say that. Take the Butler projectile——

768. Senator BECK. I am on Colonel Crispin now.

769. General BENÉT. *I do not know* that there is a dollar paid to him.

770. Senator BECK. Do you know there is not?

771. General BENÉT. *I do not know* there is not, but I do not believe there is a cent paid in regard to that matter. I make contracts for guns after gathering all the information I can from the parties concerned, and the officers that have examined them, and for all these guns I make the contracts myself. As to money being paid for any patent right, or any invention on these guns, that is something I never have heard of either directly or indirectly, and know nothing about.

772. Senator BECK. Could the manufacturers manufacture them without the patentee's consent, or could the government use them without his consent, without paying him, unless by an infringement of that patent?

773. General BENÉT. I think, from an opinion of the Supreme Court, that an officer can take a patent on anything as well as anybody else; that if you brought it before the courts, the government would be liable, because an officer is a citizen of the United States, and there is nothing in the Constitution or laws that prohibits or excludes an officer from getting a patent.

774. Senator BECK. Certainly not.

775. General BENÉT. Another thing. *I do not know* that there is a cent paid, and *I do not believe* there is; but *I know nothing about it.*

776. A counterpart to this is found in the testimony of another Chief of Ordnance on the same subject.

[See Rep. Com., No. 266, Fortieth Congress, third session, pages 53 and 54.]

Extract from testimony of Brig. Gen. A. B. Dyer.

JANUARY 18, 1868.

By Mr. BUTLER:

* * * * * * *

777. 1. Question. What is the amount that is paid, either in percentage or in gross, as you may remember, to General Rodman?

778. Answer. *I do not know* that anything has been paid. *I have no knowledge* of any amount having been paid.

779. 2. Q. As a royalty on his gun?

780. A. *None at all.* I have answered that question in writing as fully as I could.

781. 3. Q. That may be, sir.

782. A. *I have no knowledge whatever of the matter.*

783. 5. Q. How many hundred thousand dollars' worth, within bounds, have you ordered of the Rodman gun since you have been Chief of Ordnance?

784. A. *I do not remember.*

785. 6. Q. Many hundred thousands?

786. A. Yes.
787. 7. Q. Amounting to millions?
788. A. *I do not know* whether amounting to millions or not.
789. 11. Q. Then, in contracting for many hundred thousand dollars' worth of ordnance, you made no inquiry except what you saw in the printed testimony taken by the Committee on the Conduct of the War as to whether the price was increased by a royalty paid to an officer of the Ordnance Department?
790. A. *I never knew* that this was paid to an officer of the department.
791. 12. Q. Or because of a patent given an officer of the department?
792. A. I had understood this, and *I did not make any further inquiries;* had understood several years ago that this entered into and constituted a part of the cost.
793. 13. Q. What proportion of the cost of a piece of heavy ordnance would one cent per pound be as an average?
794. A. Something like one-twelfth, I suppose.
795. 26. Q. Did not you know Mr. Rodman was interested one-half in that royalty?
796. A. *I had no other knowledge than from hearsay:* I believed it.
797. 27. Q. That he had one-half?
798. A *I believe he had one-half.*

799. To attempt to legislate on the subject of improvement in ordnance without due consideration of the malign influence official inventors and official patents exercise over the subject, would be like attempting a representation of Hamlet with the title rôle left out.

800. The character of the guns contemplated in my proposals for experiments forms an essential feature of my project.

CANNON MATURED AND IMPROVED BY AGE.

801. The government has on hand about 2,000 obsolete guns. Part of these are 15-inch Rodman smooth bores, 10-inch Rodman smooth-bores, 8-inch Rodman smooth-bores, 8-inch rifles converted from 10-inch Rodman guns by lining with a tube, and two or three calibers, 100-pounders, 200-pounders, and 300-pounders, Parrott rifles; all of them "of no earthly use against iron-clads" in their present condition. Many of these guns are supplied with or mounted on iron carriages in good and sufficient condition, and a considerable amount of spherical shot and shell is to be found stored in the forts and arsenals, which can be utilized in carrying out my project for the armament of the fortifications.

802. These guns were all, or most all of them, cast many years ago. None of them have been fired more than a few proof rounds; many of them have never been fired at all, but that is not objectionable. They were all cast upon fairly uniform principles, and have been seasoned by age, by years of exposure to the annealing influences of changes of temperature from night to day, from summer to winter, and *vice versa.*

803. A chapter for which I secured admission into the report of the Joint Committee on Ordnance, Fortieth Congress [1868]—I am not newly come into this business—is suggestive of the advantages of annealing of great guns by ages of exposure to the elements. I reproduce the chapter here entire:

[Pages 188, 189, Rep. Com. No. 266, Fortieth Congress, third session.]

"TIME AND TENSIONS—EFFECT OF TIME ON TENSIONS."

"Extracts from "Experiments on Metals for Cannon and Cannon Powder." Rodman, p. 28. Report of Captain Rodman, January 30, 1867."

804. "These results appear to leave no doubt as to the superiority of the hollow over the solid cast guns *while new;* what effect time may have upon them can only be ascertained by experiments; but it is difficult to understand how time could ever so far

change their relative endurance as to cause the solid cast guns to surpass those cast hollow in this quality."

805. "The only effect of time is supposed to be to relieve the metal from the strain to which it has been subjected in cooling, it not being supposed to effect any change in its actual character."

806. "It would, therefore, appear to be reasonable and safe to predict that the *utmost* effect which time could produce would be to bring their endurance to an equality; and should this be found to be the case, which is not probable, it would still leave the hollow cast gun superior to the other; as it is believed that it may be mounted for service as soon as finished, and relied on for at least 150 rounds, for 10-inch guns; while the solid cast gun cannot be relied on for a single fire when *new;* nor can any limits, below which it shall be safe, be with any degree of certainty assigned to it after any lapse of time."

807. "The cause of this difference is believed to be that the hollow cast gun is so far relieved from strain in cooling as to remove the possibility of its ever being injured in that process; and the more perfect this relief, the more nearly will the endurance of the new gun approach that of the same gun after any lapse of time."

808. "While in the new solid cast gun it is certain that the interior is under a very heavy strain which requires time for its removal; and there is no certainty that this strain has not been sufficiently great to produce either actual cracks, or such a degree of molecular separation in the interior portions of the gun as no lapse of time will remedy."

809. "That *good* solid cast guns *may* be made is not doubted, for they *have* been made; *but that it is possible to distinguish before the trial the safe from the unsafe gun is not believed.*"

"Report on the effect of time in removing strains caused by the unequal cooling of heavy iron castings.—Major Wade's report."

PITTSBURGH, *October* 12, 1852.

810. "SIR: Since my report of the 24th of January last, on the manufacture and extreme proof of 8-inch and 10-inch columbiads, Major Bell has completed the extreme proof of two 8-inch columbiads, cast in 1846. The extraordinary endurance of these two guns induces me to submit some further considerations upon the subject."

"The mechanical tests and the endurance in firing of the three 8-inch columbiads are as follows:"

	Density.	Tenacity.	Number of fires endured.
Cast and proved in 1851	7.287	37,811	72
Cast in 1846 and proved in 1852	7.247	29,423	2,582
Cast in 1846 and proved in 1852	7.220	22,989	800

811. "The form, dimensions, weight, method of casting and cooling, and the manner of proving were the same in all. It will be seen that the gun made of the strongest iron, with a short interval of time between itsmanufacture and proof, endured the smallest number of fires; and that those made of weaker iron, but proved long after they were cast, endured the greatest number of fires. This remarkable feature in these trials suggests an inquiry as to the cause of such anomalous results."

812. If I had unrestricted control of the United States Treasury I could not procure a sufficient number of guns, so seasoned by age, and suitable for my project as those on hand. The successes achieved on Nut Island, shown in "*The Review*," already before the committee, could not have been obtained except with guns *seasoned by age*, as those I used successfully on that occasion were, and even with such guns no part of the success could have been obtained except with projectiles such as would not change their form permanently in the gun, and which were supported centrally in the bore with windage all around alike.

Projectiles of such *form*, that the *upsetting* under the action of the severe powder used in tremendously heavy charges would not result in swelling their outer ends to such an extent as to bring any part of the

surface of their bodies into rubbing or indenting contact with the surface of the bore to abrade it or create undue friction.

That I did obtain these favorable and necessary conditions by design, and not by accident, is conclusively proved by the uniformity of results.

813. An astute Senator, referring to these results during the debate on amendments to the naval appropriation bill at the end of last session, said:

814. "*These things have once been accomplished; they have been accomplished by design; they have been accomplished through the genius of an American citizen; and, having been once accomplished, they can be accomplished again. What has been done on scientific principles with certain results, of course can be repeated. If the Government of the United States can get the advantage of such inventions, such enterprise, and such exhibitions of genius at so little cost, I can see no reason why we should not avail ourselves of the opportunity.*"

815. Despairing of ever getting my valuable inventions utilized other wise, I had made a proposition to convert fourteen guns, conduct an elaborate series of costly experiments near Washington openly, furnish a floating battery, 160,000 pounds of iron target, powder, projectiles, implements, iron carriages, labor materials, transportation, &c., all at my own cost, entirely without cost to the government, except the supply of the guns to be converted, which were to be returned after conversion and proof. Of this the Senator said:

816. "These fourteen guns can be taken of obsolete pattern, as I have observed, with four gun-carriages and instruments to measure the velocity of the projectiles, and they can be converted, experimented upon, and returned. * * * They can be returned by the 1st of March, 1883, the government losing nothing at all, and gaining the advantage of the experiments and the proof of the fact whether or not these experiments are to be made successful in the armament of ships and the heavy forts upon the coast."

817. "*It is useless for us to undertake to build a navy, as we all confess we must do, unless we have some better armament than we have now. The truth is we have not an efficient gun in the United States Navy to-day as against the iron-clads of Italy, of Spain, of England, Germany, or even Chili.* WE HAVE NOT AN EFFICIENT GUN IN THE AMERICAN NAVY."

818. In the course of the debate the same Senator said further:

819. "The proposition which was admitted is one of very great value, I think, to the country. That is my opinion about it. Of course it is not the opinion of an expert, a scientific man, but it is predicated upon a state of facts which is unquestionably true, and which, being true, reveals the most important discovery, I may say, that as yet appeared in the history of the world, as I conceive, in the framing of guns and projectiles of heavy caliber."

820. "The particular plan upon which this is sought to be done has been heretofore experimented upon under the supervision of officers of the Navy, *and the fact, as revealed by the experiments which the officers of the Navy themselves have reported to the government, is "that the inventor has succeeded in penetrating fifteen inches of iron and fourteen feet of hard gravel in addition with a charge of only seventy pounds of powder, a performance which has never been equaled, not even approached with less than three times the charge of powder, even with a gun of one-third greater weight and nine times the cost.*"

821. The amendment prevailed, but adverse influences caused it to be rejected in a conference between the two houses of Congress. A patriotic citizen of great wealth, having unprotected millions worth of property in New York, had promised me financial aid in carrying out the enterprise if I could secure official recognition of my experiments and the supply of the guns by act of Congress; but that fact was not respected by the lobby of the ordnance wing, the project failed asstated.

822. After twenty-two years of steady pursuit of the project of improvingordnance, during which I have expended about one million of dollars for experiments principally from private resources, unaided by the government (in fact the opposite, for there is due me for expenses incurred, material furnished, and labor performed for the government under contracts made and fulfilled in 1861, 1862, and 1863, nearly half a million of dollars), and in consideration of the remarkable results of the Nut

Island experiments, I feel confident that I am not asking too much to claim a careful unprejudiced consideration of my proposal laid before the committee, and the reasonable appropriatiation of $200,000 for the experiments specified therein, and $100,000 for converting 200 guns of those matured by age, if the experiment succeed as before. If this is done I confidently believe it will result in the solution of the ordnance problem.

Respectfully,

NORMAN WIARD.

FEBRUARY 1, 1883.

COMMUNICATION OF NORMAN WIARD.

The CHAIRMAN submitted the following communication from Norman Wiard:

GUN-BURSTING CONSIDERED.

THE RATIONALE, THE MODE, AND THE REMEDY.

"It is the unexpected bursting which does the mischief."—Admiral DAHLGREN.

"It is better that millions should be expended in time of peace and from an overflowing treasury than that a single gun should burst in action."—T. J. RODMAN, *Captain of Ordnance.*

"It has been a primary principle in making cannon that the larger the caliber the less was the probability (I might say certainty) of its endurance."—Admiral DAHLGREN.

AN ESSAY FOUNDED UPON THEORY, READING, ORIGINAL STUDY, AND PRACTICE.

BY NORMAN WIARD.

[Written for the information of the Senate Select Committee on Ordnance, January, 1883.]

823. SENATORS OF THE SELECT COMMITTEE ON ORDNANCE: I have devoted twenty-one years of the best part of my life—more than one-third of the whole of it—to the solution of the ordnance problem.

Beginning in 1861 (August 1) with a better than ordinary practical experience as a worker of metals in large masses, and with a good reputation for mechanical skill and invention, I had already fabricated from my own designs three complete batteries of steel rifled cannon for field service, under a contract awarded me on the 28th day of May of that year. The guns were ready for service on the 1st of July, and were actually inspected, approved, commended, and received from me on the 3d of July, by the parties with whom I made the contract, representing the city of New York.

824. On the 1st of August, 1861, I undertook to fabricate a large number of steel 50-pounder Dahlgren guns for the Navy.

825. The guns were made quickly and skillfully in strict conformity with the "drawings and directions" supplied to me by the Ordnance Department of the Navy, the drawings and specifications having been prepared by Captain Dahlgren.

826. The guns were essentially Dahlgren guns. In design, caliber, outline, and dimensions they were identical with those finished previously at the Washington navy-yard under Captain Dahlgren's personal supervision, except that those of my fabrication were made of steel, which had a tensile strength of 90,000 pounds to the square inch of section. Those made at the navy-yard were made of cast iron, having a tensile strength of about 28,000 pounds.

827. If guns of both kinds had been subjected to hydraulic pressure in competition alone, without any other quality of force acting to burst them, those of my fabrication, as I made them, would have been four times as strong as the ones made of cast iron at the Washington navy-yard.

828. Any of my guns, strong as they were, could have been burst on a cold day by inserting a red-hot bar of iron, cylindrical in form, into the gun.

829. A cast-iron gun of the same model and dimensions, cast solid and cooled entirely from the exterior, however slowly, could not be readily burst in that manner; while a Rodman gun cast hollow and cooled

from the interior is liable to burst spontaneously, as it were, on account of the tension inaugurated by cooling, except it has been long exposed out doors to the annealing process of exposure to the elements for years, and to the changes of temperature between winter and summer, night and day.

830. The guns were essentially Dahlgren guns, and the department selected the material of which they were to be made under the mistaken idea, as it afterward proved, that the strongest material would make the strongest gun.

831. The following is the order upon which the work was undertaken, but in addition to this it was by verbal agreement understood that a large number, not less than fifty, would be taken:

[Forty-first Congress, first session, Senate Ex. Doc. No. 12.]

"BUREAU OF ORDNANCE AND HYDROGRAPHY, NAVY DEPARTMENT,
"*Washington City, August* 1, 1861.

832. "SIR: In answer to your proposals of yesterday's date, I have to inform you that the bureau, being desirous of procuring rifled cannon for the use of the Navy at the shortest possible notice, will purchase guns of your fabrication of semi-steel: *Provided,*

833. "1. That the guns made shall conform strictly to the *directions and drawings* herewith presented.

834. "2. If you will offer five guns made as above stipulated, the bureau will receive them, subject to proper inspection, and, if accepted, pay you at the rate of eighty-five cents (85c.) per pound.

835. "3. It is to be distinctly understood that the bureau is to be the judge of your compliance with the conditions of the agreement, and binds itself to the purchase of no more than may be ordered from time to time.

836. "You will please notify the bureau if you accept the terms herein specified.

"Very respectfully,

"AND'W A. HARWOOD,
"*Chief of Bureau Ordnance and Hydrography.*

"MR. NORMAN WIARD, *Washington, D. C.*"

837. And the following additional order was received:

[Forty-first Congress, first session, Senate Ex. Doc. No. 12.]

"BUREAU OF ORDNANCE, NAVY DEPARTMENT,
"*August* 7, 1861.

838. "SIR: The bureau wishes to contract with you to make some semi-steel howitzers, 12-pounders, to be made after a model gun which will be forwarded to you by express. Will you please notify the bureau whether you will undertake it?

839. "The guns to be made subject to such inspection and conditions as provided for in your other agreement.

"Very respectfully, your obedient servant,

"A. A. HARWOOD,
"*Chief of Bureau.*

"MR. NORMAN WIARD."

[Extract of letter from Chief of Bureau, stating a large number of guns will be wanted (report of Joint Committee on Ordnance].

"WASHINGTON CITY, D. C., *August* 12, 1861.

840. "While, as I explained to you, it would be impossible for the bureau to state the exact number of rifle cannon and howitzers required, *I take this opportunity to* REPEAT *to you that a large number will be wanted,* and, as they are wanted directly, the establishment which can make them quickest and of good quality will necessarily have the most to do. *The order will be renewed as soon as the bureau hears from you of the completion of each batch of five of the large guns; and it will be the same case with regard to the howitzers,* provided you can carry on the work at both, at the same time, without retarding the delivery of the larger guns, which will be most wanted.

"Very respectfully, your obedient servant,

"AND'W A. HARWOOD,
"*Chief of Bureau.*

"NORMAN WIARD,
"136 *East Thirty-third Street, New York.*"

"BUREAU OF ORDNANCE AND HYDROGRAPHY, NAVY DEPARTMENT,
"*Washington City, August* 28, 1861.

841. "SIR: *In assenting to the making of five more steel guns by your establishment* it was understood between us that the guns made under this new order are to be paid for according to the reduced rates proposed by you, namely, 80 cents per lb.

842. "I must also remark that *the reception of these guns depends necessarily upon the proof*, and therefore any expedition which may seem desirable to the manufacturers is entirely at their own risk.

Very respectfully,

"AND'W A. HARWOOD,
"*Chief of Bureau.*

"Mr. NORMAN WIARD,
"136 *East Thirty-third Street, New York.*"
(Forty-first Congress, first session, senate Ex. Doc. No. 12.)

843. The following shows the model of the guns as designed by admiral Dahlgren [Fig. 1]. They were 50 pounder rifles, caliber 5.1 inches.

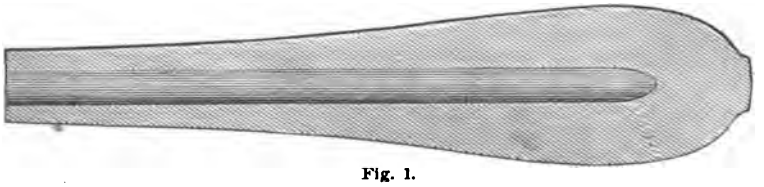


Fig. 1.

The blocks of steel from which they were made weighed 8,000 pounds each—the largest solid masses of that material that had at that time been fabricated.

"BUREAU OF ORDNANCE AND HYDROGRAPHY, NAVY DEPARTMENT,
"*Washington City, August* 6, 1861.

844. "SIR: Herewith you will find transmitted a draft of gun to be made, according to your agreement, of semi-steel.

845. "It is desirable that the bureau should have, after the first gun is finished, specimens by which the tenacity and density of the metal may be established.

846. "Care must be taken in the fabrication to verify the preponderance of the breech for about 700 pounds before furnishing the trunnions.

"Very respectfully, your obedient servant,

"A. A. HARWOOD,
"*Chief of Bureau.*

"NORMAN WIARD, Esq.,
"*No.* 136 *East Thirty-third Street, New York.*"

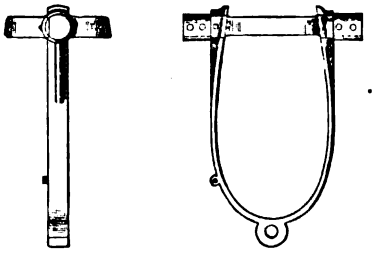


FIG. 2.—Drawings for trunnions, Dahlgren's patent.

847. Thirteen of these 50-pounder guns were made, and 22 of the smaller boat-howitzers, when the bureau directed one of the guns should be submitted to extreme proof. It was fired 490 rounds, and then, being in good condition, the authorities determined to accept it.

"BUREAU OF ORDNANCE AND HYDROGRAPHY, NAVY DEPARTMENT,
"*Washington City, October* 18, 1861.

848. "SIR: 1. The bureau accepts the trial gun recently fired by the Inspector of Ordnance, *and you are requested to complete the remaining fifty-pounders with all possible dispatch.*

849. "2. *As soon as the guns are inspected and proved, they are to be delivered at the New York navy-yard.*

850. "3. With reference to your proposition for finishing VII½-inch rifles and XI-inch shell-guns from rough castings, the bureau will authorize Commander Hitchcock to make whatever arrangements he may deem expedient, in view of carrying out the interests of the government, and he will likewise be directed to communicate with you on the subject.

"Very respectfully,

"AND'W A. HARWOOD,
"*Chief of Bureau of Ordnance and Hydrography.*

"MR. NORMAN WIARD,
"136 *East Thirty-third Street, New York.*"

851. The above letter is from page 35, Ex. Doc. No. 11, Forty-first Congress, first session.

852. This gun was fired with service charges of fine powder, 5 pounds to the charge, and with expanding projectiles (Hotchkiss patent) weighing 50 pounds each. It was fired with great deliberation, *with long intervals between the rounds;* at every tenth round the bore was washed out, carefully examined, and measured. It was found to be entirely unaffected by the firing, except that the vent was enlarged.

853. Two other of the 50 pounders and five boat howitzers were then fired, ten proof-rounds each, and, being uninjured, were accepted and delivered at the navy-yard in accordance with the instructions of the bureau. All the above guns were fired with deliberation.

854. Two other of the 50-pounders were afterwards fired rapidly on an extremely cold day accompanied by a sleet that covered the guns with ice. Each burst at the ninth round, having been fired at the rate of nine rounds each in four and a half minutes; another was found to have a slight flaw in the bore, which prevented the insertion of the second shot and it was withdrawn from official test, but was however fired with deliberation to note if any enlargement of the defect resulted. It withstood the test and was removed to the works, afterwards subjected to a very severe private test—triple charges of powder, 15 pounds—and a bar of iron turned 5 inches in diameter and as long as the bore of the gun, so that when it was inserted it protruded at the muzzle a distance equal to the length of the cartridge. This gun was fired in a stone quarry at the foot of Thirty-eighth street, East River, New York, and was laid on skids with the muzzle pointing towards the rock face of the quarry with the end of the projectile abutted against the rock. The gun was thrown back about 40 feet and turned a somersault. The cylindrical bar was reduced in length by upsetting about 5 inches, and had been expanded into the grooves of the rifle, filling them completely for a considerable part of the length of the bore. The gun was uninjured.

855. Another of the lot remaining on hand was subjected to the same ordeal, but previous to rifling the long projectile abutted against the rock as before, jammed in the bore, and was not ejected; nearly all the gas developed by the combustion of the large charge of powder escaped through the vent. The long projectile was removed by boring, the same as if it had been part of the original forging for the gun.

856. The gun previously referred to as defective, in which the original flaw was found, and which was withdrawn from inspection, was afterwards loaned to various parties having projectiles newly invented to test, and was used at West Point for that purpose, as the following

shows. But there was *always long intervals between the shots* during all the firing.

[Extract from testimony of Clifford Arrick before the Joint Committee on Ordnance.]

857. "Q. What do you know, if anything, in relation to the Wiard semi-steel 50-pounder guns made for the Navy in 1861, in relation to their strength, endurance, or the workmanship exhibited in their fabrication?—A. One of the guns made by Norman Wiard at New York, a semi-steel 50-pounder (Dahlgren model), was taken by Stafford & Ward to West Point in the fall of 1863, and was used by them in some experimental firing to test the quality of the Stafford subcaliber projectiles. This same gun had been once before at West Point for the purpose of testing the projectile projects of Horace Day, and had been provided for that purpose with an additional vent some four to six inches toward the muzzle, and in all these experiments the gun was subjected to extraordinary test, and such as it would not be subjected to in service with the ordinary charge and service projectiles. Great confidence was felt by all parties, including the officers, I think, who sometimes attended the firing, in the capacity of this piece, and it seemed to undergo every ordeal to which it was subjected without exhibiting the least evidence of weakness or deterioration, and was in as good condition at the close of the experiments as when first mounted. The workmanship (internal and external) seemed to be of the highest order, and I think this gun, to be used for the purpose of testing the strength of projectiles under the action of heavy charges and quick-burning powder, was of great value to the government and the parties using it. The apprehensions felt by the Chief of Ordnance of the Navy Department (Captain Wise) as to the Parrott rifles used for the same service did not seem to be entertained by anybody as to this gun. Very frequently Captain Wise required these same gentlemen to give bonds for the safety of the Parrott guns when the same kind of projectiles and lighter charges were used. More than one Dahlgren gun, I believe, was destroyed in this way, but the Wiard one referred to seemed to have no guardian and to need none. Nor did it seem to have or need any friends. It was subjected to all sorts of outrage, and proved equal to every emergency."

858. The guns which burst broke into three fragments, as shown on the

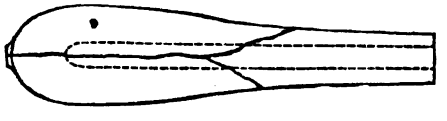


FIG. 3.—Line of fracture of the burst steel guns.

cut. When the guns were thus opened the ruptured surfaces exposed no flaws; on the contrary, a uniform fine crystalline texture. Upon rubbing the tips of the fingers across the surface fine sharp points were found projecting, which scratched the skin as if with hundreds of needle points, indicating superior strong metal. The official inspector who was present said:

[*From the testimony of R. B. Hitchcock, before the Joint Committee on Ordnance, relating to proof of Wiard guns.*]

859. "Q. And if a first gun of a class stands 1,000 rounds, you are ready to accept the others always upon the test of the 10 rounds?—A. Yes; 10 rounds always. Those numbers are fixed. I have no remembrance whatever now of any defects being found about these guns that would cause one to be picked out as inferior to the other. There have been no guns presented to the government that presented a better appearance than they did.

860. "Q. Did you find that gun deteriorate under the experiments of extreme proof?—A. It stood remarkably well.

861. "Q. I think you said that some of these Wiard guns, fired with 5-pound charges, burst at 10 rounds?—A. Yes, sir.

862. "Q. Did those that burst show any defects, either in the welds or by exhibition of laminæ?—A. I think not, sir.

863. At the time the guns referred to burst, thirteen of the 50-pounders had been made and $80,000 had been expended for appliances, materials, labor, &c.

[*From the record of the Joint Committee on Ordnance.*]

"WEST POINT FOUNDRY,
"*Cold Spring*, N. Y., *December* 23, 1861.

"NORMAN WIARD, Esq., *New York:*

864. "SIR: I am directed to furnish you with the information contained in the following letter:

"BUREAU OF ORDNANCE AND HYDROGRAPHY, NAVY DEPARTMENT,
"*Washington City, December*19, 1861.

865. "SIR: The bureau desires you to inform Mr. Norman Wiard that neither the 50-pounder cannon nor the semi-steel rifled howitzers will be received by this department.

"I am, very respectfully, your obedient servant,
"ANDREW A. HARWOOD,
"*Chief of Bureau of Ordnance and Hydrography.*

"Commander R. B. HITCHCOCK,
"*Inspector of Ordnance, Cold Spring.*

866. No part of this large outlay has ever been reimbursed by the paternal government under which we live. The two guns delivered at the navy-yard were afterwards sold at auction by the Navy Department. The money received from the sale was covered into the Treasury. Some false reports were made to Congress by the Chief of the Bureau of Ordnance, Navy (Capt. H. A. Wise), and which it is easy to prove by documents over his own signature were false, as well as that he knew they were false—and yet the maker of the guns has never received one cent for them, although the Constitution provides that, "private property shall not be taken for public use without compensation." Ordnance authorities in this country are contemptuous of the law and are seemingly without respect for truth or justice, as I have shown in previous papers presented to this committee.

867. The same Chief of Ordnance who caused my property to be sold testified as to the regulations relating to the reception of guns from makers.

[Extract from the evidence of Capt. H. A. Wise, Chief of the Bureau of Ordnance, before the Committee ond the Conduct of the War, page 27.]

868. "Answer. * * * We enter into an agreement with a founder to make, say, 50 guns. We then determine the quality of his metal, and he is obliged to lay in enough of that metal to make 50 guns of the caliber agreed upon. We watch the treatment of his first gun closely, as, in fact, every other; but we select one of the first five guns and subject it to a powder proof of the ordinary service charge up to 1,000 rounds. If the gun does not break or show signs of undoubted weakness under this firing, then we pay for the gun and lay it aside as the *standard*. The remaining 49 guns, which must all conform to the standard, we prove by firing 10 service charges."

869. So it can be seen that arbitrary regulations, as well as the laws and the Constitution, are violated when it suits the purpose of such persons. In relation to these premises, I said, near twenty years ago:

[From the memorial of Norman Wiard.]

870. "It could not be that the failure of one, two, or three guns, of a large number intended to be manufactured of a novel material and of large size, could be accounted by the Ordnance Department of either branch of service a sufficient ground upon which to declare a contract for the manufacture of guns annulled, and thus violate the good faith of the government and disregard the rights and equities of a contractor. In this case the contractor, as well as the department, apprehended some failures in the production of the first lot of guns, the government taking the responsibility of the plans, and the contractor only engaging to faithfully execute them. The department well knew—it could not help knowing by the reported results of experiments conducted at government expense—how uncertain was the production of safe guns of large caliber of any material. The history of all attempts to produce such guns in this or in any other country is a history of failures. The large rifled

guns in United States service are principally those of Mr. Parrott, and the records of actual service show them to be utterly unreliable—nay, more dangerous to those using them than to an enemy. Witness the first attack on Fort Fisher alone. Hundreds of his guns have failed in proof or in service, exhibiting a most remarkable lack of uniformity of endurance; and even his trial guns, of some calibers, have exhibited less endurance than the trial gun submitted by your memorialist, which withstood the test before mentioned (490 rounds) without any injury whatever. Nevertheless the department neither abandoned its contract with Mr. Parrott, nor was he asked to refund any portion of the large amounts paid to him under the same. Several of the XV-inch guns burst in the Fort Pitt foundry spontaneously, before they could be submitted to proof at all; and many of them approved as trial guns have exhibited but low endurance during experiments; yet large numbers of them have been taken, put into service, and, upon their failure, no annulment of contract has followed, nor has any demand for restitution of payments been made."

871. Although I have never been repaid for my outlay in a commercial sense, I learned something in relation to the cause of the bursting of guns worth more than all I expended.

872. The government too has lost more than $50,000,000 through the failure of its agents to appreciate the value of the knowledge secured by me while I was engaged upon this and cognate enterprises, and by the resistless force of circumstances the government has had to pay and pay, but not to me. It owes me just as much as it did on that account—but of that no matter now; a mission was indicated for me; I have labored on it ever since, and have refused to be diverted from it.

873. While I was engaged upon the steel guns Captain Dahlgren was engaged in making cast-iron guns of the same model and caliber at the Washington navy-yard, and Mr. Horatio Ames undertook to produce wrought-iron guns of the same the caliber according to the same drawings and directions as those under which I was working, and Captain Parrott of the West Point foundry furnished his first 100-pounder simultaneously with my first steel 50-pounders. I was informed by the Navy Department, soon after I began operations, that two of Captain Dahlgren's 50-pounders had undergone an extreme proof, each having endured 1,500 rounds. (but did not then inform me that others had burst after a few rounds). The firing of one of them was still continued. As the tensile strength of his cast iron was only between 27,000 and 28,000 pounds to the square inch, while my guns were being made of steel of which the tenacity when tested proved to be between 90,000 and 100,000 pounds to the same area of cross-section, I confidently expected that guns of my fabrication would prove far more effective and powerful than any others of weaker material. The wrought-iron guns made by Mr. Ames were fabricated of material having a lowest tenacity of 60,000 pounds to the inch of sectional area. Inasmuch as the bureau had notified me that "the establishment which could make them quickest and of good quality would necessarily have the most to do," I did not hesitate to exert myself, or to invest largely in such appliances as would hasten the work. I had my first gun ready, except rifling, in twenty-eight days from the date of my order to begin. My competitors [one of whom had the United States Treasury to back him] were each more than a year in producing their first guns. Mr. Ames testified—

[Extract from affidavit of Horatio Ames, dated Washington, April 4, 1863, from report of Joint Committee on Ordnance.]

874. "And deponent further shows that, under the understanding and agreement made as aforesaid, he did at once proceed to divert and employ his entire works and his entire capital of $400,000, giving his entire time, attention, and labor, in inventing and making the necessary tools and machinery, &c., with an expenditure of some ninety thousand (90,000) dollars, and the employment of an average of fifty (50) men per day for over a year, to produce five (5) sample guns as required, having failed on eight (8) different guns before succeeding in getting one gun fit to deliver and stand the necessary tests and proof."

875. My first conclusion after seeing my first gun burst was that the metal had deteriorated while undergoing the forging, although all the indications were that it was very strong. I caused test pieces to be taken out from different portions of the gun which, when submitted to test, showed tenacity above 90,000 pounds. I caused several specimens to be cut out twelve inches long and half-inch square, which at my request were drawn out cold into wires, each nearly half a mile in length, by Mr. Roebling at his wire works at Trenton. Having such tenacity and ductility the wonder was why the guns burst without first enlarging in the bore. As it is an axiom in mechanics that "everything bends before it breaks," I applied myself at once to the solution of the problem.

876. I fired a number of small guns [12-pounders] made of the same material as rapidly as possible for a large number of rounds and until the firing had to cease lest the heat of the gun should prematurely ignite the charge, but in no case did any one of such guns under such firing burst. I then burst two large guns by heating a long cylinder of iron slightly smaller than the bore and inserting suddenly into the bore. The guns burst in both cases after a few minutes. On one occasion I had heated a shaft of iron of proper size white hot and inserted it into a 42-pounder gun, where it remained 16 minutes; the gun did not burst. I was about to remove it for reheating when I noticed that the gun was pretty hot on the outside; I threw a bucket of water upon it, when it burst with a loud report. Before I had progressed far with my preliminary experiments, I prepared and read a paper on the subject before the polytechnic club of the American Institute, New York (June, 1867). Mr. Horace Greeley was present, and requested me to communicate the substance of my remarks to The Tribune for publication, which was done; this was soon after reproduced in a pamphlet illustrated with the Tribune cuts, and, 1863, Mr. Alexander Holly requested permission to republish the same article in his "Ordnance and Armor." The following is quoted from Mr. Holley's work:

877. "Mr. Norman Wiard, of New York, has treated the subject with great ingenuity; his views and illustrations will be found in the appendix. Other authorities * have referred to the effects of rapid firing upon the durability of cannon. Mr. Mallet says: "The expansion of the interior of the gun, acting tangentially, exercises against its rigidly resisting exterior a powerful splitting strain. The elongation of the interior of the chase, from the same cause, drags or forces the exterior to elongate along with it."

HOW GUNS BURST.

BY NORMAN WIARD, ESQ.†

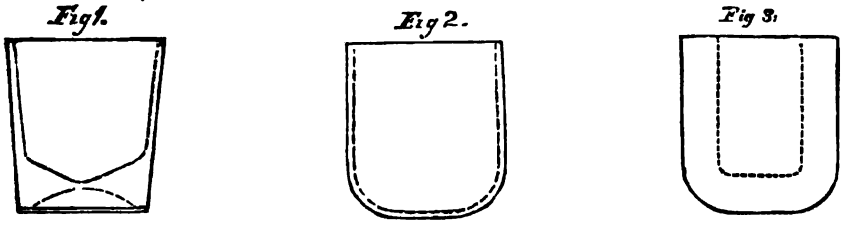
878. When gunpowder is fired from a gun, two prominent phenomena are to be observed: the wonderful expansive force which ejects the shot, and the heat which results from the combustion of the powder.

879. Let us exhibit the effect of heat on metals by a familiar experiment. Pour boiling water into a glass tumbler; the heat, communicating

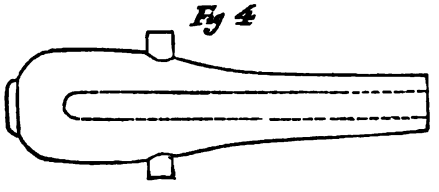
* Mr. Longridge says: "This is, probably, the cause of guns being more liable to burst when they get hot. It is not that the iron is weaker, for Mr. Fairbairn has shown that up to 600° the strength of cast iron is not materially diminished; but when the gun is heated, the gunpowder gets warmed and burns more rapidly, and the force is generated and applied more suddenly."—*Construction of Artillery, Inst. C. E.*, 1860.

† "Great Guns; the cause of their failure, and the true method of constructing them."—Norman Wiard, 1863.

more quickly to the thin sides than to the thick bottom, breaks the glass from unequal expansion. If we wish the tumbler to withstand the sudden communication of heat, we must make it everywhere thin alike, so that the heat may pass through it uniformly and quickly. Hot water may then be poured into it with impunity. * * *



880. Now this unequal communication of heat has a similar effect upon large guns. This may also be illustrated by a glass model of a gun (Fig. 4), which, although strong enough to withstand a pressure on



the inner surface of 4,000 pounds to the inch, would be broken by the insertion of a heated rod of iron of smaller diameter than the bore, even though so inserted as not to come in contact with its sides, and not accompanied by any pressure against the surface. * * * If, however, after waiting a time *for the model to be slowly heated throughout its whole mass*, the outer surface of the gun be touched by the wetted finger, the evaporation of the moisture will make the heat sufficiently unequal, and the model will break. This example may exhibit the direct cause of the bursting of the 100-pounder Parrott gun, on the steamer Naugatuck, on the James River, before Fort Darling, when other guns of the same kind on the steamer Galena, though fired with great rapidity, and oftener, did not burst; all of which may be accounted for by the fact that it was raining at the time, and that the gun of the Naugatuck being on the upper deck and exposed to the rain, was subjected to a more unequal heating than the guns of the Galena, which were between decks. I have stated that guns are more *likely to burst* when fired on *cold* or *rainy* days, and offer the following examples in corroboration: First, two large steel guns, of my fabrication, burst under such circumstances; then this example of the gun on the Naugatuck, and two guns referred to in the table,* are among many other similar cases I have noticed.

881. There being two forces acting upon the guns which burst, one the direct pressure of the gases evolved from the powder, and the other resulting from the expansion of the inner metal of the gun, both forces acting in the same direction, and nearly at the same time, it would seem difficult to show one to be pre-eminently the cause of the fracture.

* * * * * * *

* Mr. Wiard constructs a table from experiments recorded by Captain Rodman, showing a much greater endurance of guns with proof rounds in fair than in rainy weather.

882. The fractures of large guns upon improved models, with a light chase and heavy reinforce, that have burst with the service charges, are curiously alike in their direction, running through the center of the breech and reinforce, to a point usually forward of the trunnions, and branching off at either side, generally breaking the gun into three great pieces. This direction of fracture holds, whether the gun has the outlines of the army columbiad (Fig. 5), of the Dahlgren gun (Fig. 6), or of

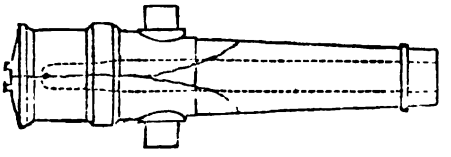


FIG. 5.

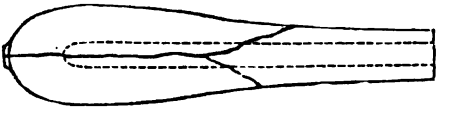


FIG. 6.

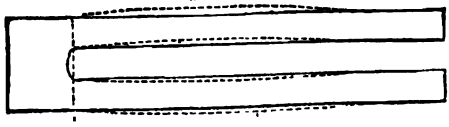
the Parrott gun with its strong wrought-iron reinforce, and whether the gun be made of steel or of cast iron. It would scarcely be expected, when the Dahlgren guns burst, with this great thickness of metal about the breech, that the fracture would occur through the cascabel, where the metal has more than twice the thickness exhibited in the army columbiad, but this principal direction is usually the result.

883. Guns sometimes exhibit additional fractures to those represented above, and this occurs when the thickness of metal is continued farther forward towards the muzzle, having the same effect as if a tire or strong band were placed upon the gun at the place where the fracture usually branches off to either side, thus delaying the longitudinal fracture until the expansion lengthwise of the inner metal is greater than the *elasticity* and *ductility* of the reinforce permit when the cross fracture occurs. It may be said, then, in brief, that the fractures at right angles to the plane of the bore are caused by the lengthening of the inner metal about the bore by heat, while the outer metal remains the same length, or with less expansion of length, until ruptured, and that longitudinal fractures are due *principally* to the enlargement of the inner metal by *heat* in the direction of the diameter, or *radially*. If the gun be parallel all the way to the muzzle the cross fractures will occur more frequently along the reinforce, because in that part it is exposed to the highest temperature, and, consequently, the greatest expansion of length. * * * It is a corroboration of this theory that the guns of the Dahlgren model, with more than double the thickness of metal behind the chamber, though made of the strongest material, should break in the same direction, forward of the trunnions, but sometimes exhibit only cross fractures (when made of cast iron) to the rear of the trunnions. It is evident that the model is best in which the direction of the fracture is least uniform, but a properly constructed gun should not burst at all.

884. The gun, however, is usually broken through the breech—the strongest part of the gun—and beyond the range of the pressure, which is, of course, limited to the bottom of the bore or chamber. The diagram (Fig. 7) in Captain Rodman's book, p. 43, exhibiting the various kinds of strain to which a gun is subjected at each discharge, considers

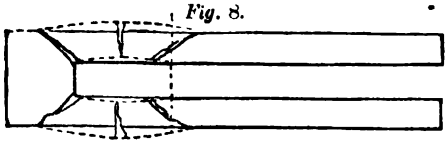
the gun as if made up of staves, and really exhibits only the strain from the expansive force or direct pressure of the powder, bending the staves outward; and page 47 of the same book, by diagram (Fig. 8), the direc-

Fig. 7.



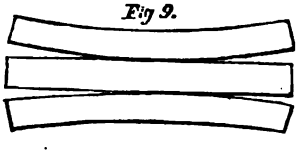
tion of fracture due to such strain, not through the breech, but running at an angle to the plane of the bore.

Fig. 8.



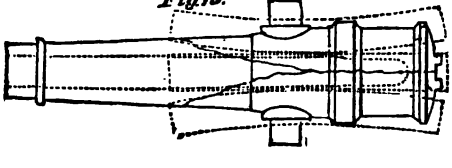
885. To show that it is improbable that the direct pressure of the powder should be the cause of fracture, as exhibited by the gun actually broken by firing, prepare three plates of metal, say 4 inches thick, 12 inches wide, and 60 inches long, with plane surfaces; the middle one, on being heated to 1,600°, will be found expanded one-sixtieth part of its length, or will be 61 inches long. On placing it between the other two (Fig. 9), a part of its heat is immediately communicated to their

Fig 9.



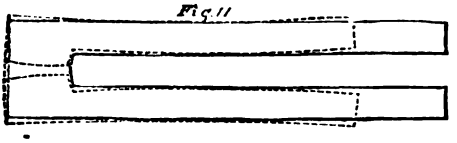
contiguous surfaces only. The expansion of one surface of the outside plates, while the other surfaces remain cold, warps the latter to the form of a segment of a circle. Now, supposing them placed upon the diagram of a burst gun (Fig. 10), the center metal of which has been

Fig 10.



heated by the combustion of powder, it is evident that the fracture in the particular direction exhibited must have resulted from the unequal expansion of the gun by heat, and a diagram exhibiting these curves, the result of this expansion, will be exactly the opposite of the curves on the diagram by Rodman (Fig. 7), and will account for the breaking of the gun through the breech beyond the range of the pressure made by the powder (Fig. 11).

886. That the fracture almost always intersects the vent has been heretofore referred to the weakness resulting from drilling away part of the metal, but on page 355, Major Wade's Reports on Metals for Guns, we find that after a gun had been put to extreme proof, and exhibited signs of fracture, a hole was drilled one inch forward of the base-ring and four inches from the line of the vent to a depth of four inches, and of the diameter of one and a quarter inches. The gun was then fired with double charges of powder, and with a bore full of balls and wads,



eleven times, to bursting. Although the piece burst into more than twelve fragments, one of the fractures intersecting the vent, it did not split through the large hole, showing that the gun had strength to resist the pressure of the powder, but burst, notwithstanding the drilling away of so large a part of the metal, from the communication of heat. The true cause, probably, of the intersection of the vent by the fracture was the communication of heat to the surface of the vent, thereby expanding a column of metal about it. The surface of the larger hole was not so heated and expanded.

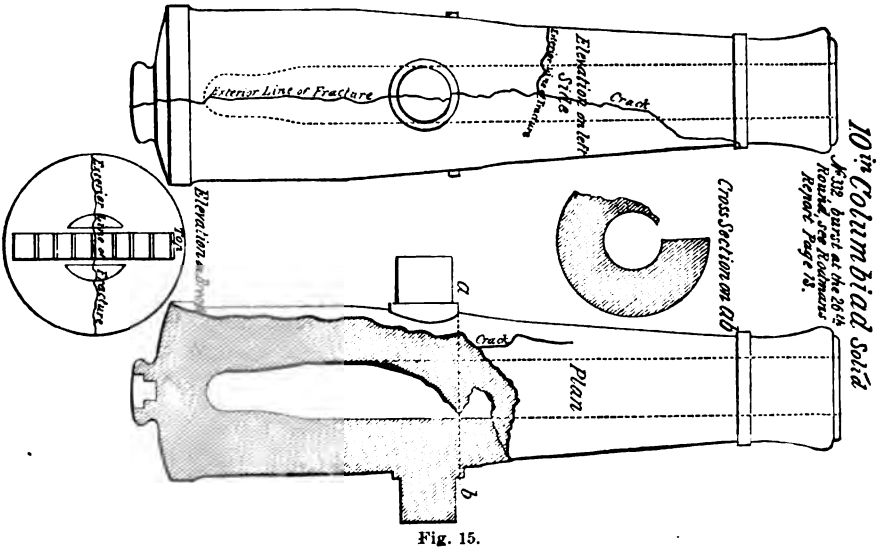


Fig. 15.

887. There is a further corroboration of this theory to be found on page 13 of "Rodman's Reports." Here, Fig. 15, we see a large gun which has burst by the throwing off nearly one-half of the reinforce. On the diagram is seen a cross-section on the line *a b*, which shows a thin point or tongue of metal left standing attached to the principal unbroken part of the gun. If it was the direct pressure of the powder gases acting outwards against the surface of the bore to burst off half the reinforce, why was this tongue of metal left? Surely a pressure against the bore sufficient to carry the larger and heavier part would also have burst this outward; but it seems to have been left at the time of the acci-

dent as a witness to prove that it was not the pressure of the gases of the powder which performed the principal work of bursting the gun.

888. Mr. Holley, paragraph 338, says:

889. "Mr. Wiard proposes to remedy this cause of failure in two ways: 1st, by shaping the gun so that it can expand without excessive strain. This plan will be referred to under the head of cast iron (383). 2d, Mr. Wiard proposes to make the tubes of a gun of different metals, arranged with reference to their respective elongation by heat. An inner tube of steel, although in direct contact with the heated gases, would not expand much more than an outer, less exposed tube of bronze; so that the initial strain would be little disturbed."

890. And on page 327 proceeds to describe the first plan referred to:

991. "MR. WIARD'S PLAN.—Mr. Norman Wiard, whose ingenious and important speculations on the bursting of guns by the heat of firing have been referred to in the foregoing chapter, has received a large order for heavy cannon, based upon the endurance of either one of two test guns. The engravings illustrate the general features of his plan, but not the exact proportions; these are the subject of extended experiments and calculations not yet perfected."

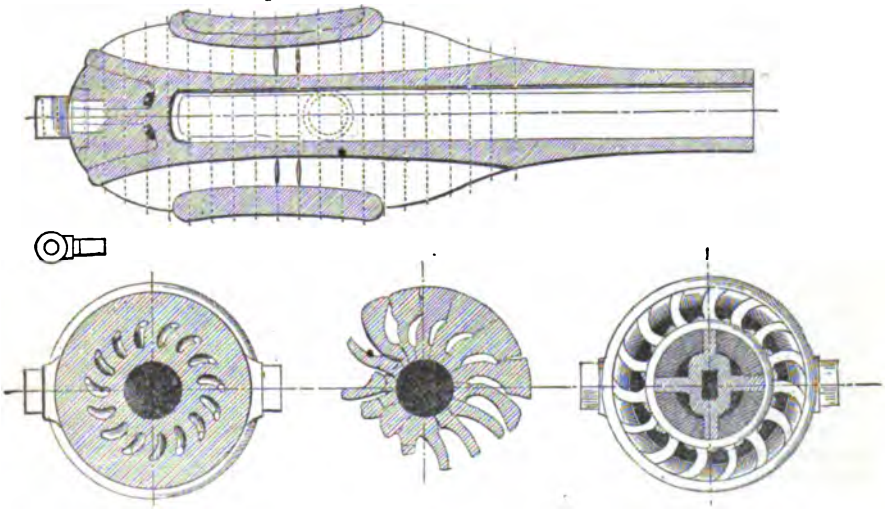


FIG. 16.—Drawing showing the gun in various sections and a rear elevation.

992. "The gun is said to have the same diameter and length of bore as the navy 15-inch gun, and about nine inches greater external diameter, and is to weigh 43,000 pounds. The interior parts may be cooled uniformly by water passing through the

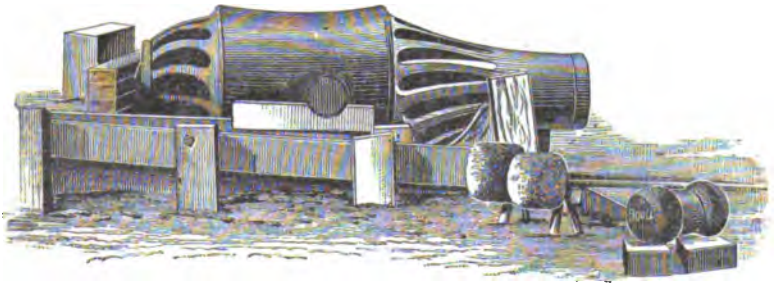


FIG. 17.—The double projectile, 900 pounds. The first experimental gun as made.

cores between the ribs, and in the bore, upon Captain Rodman's plan. The exterior part or reinforce, being thicker than the other parts, *will cool last after casting*, and is by this means intended to compress the barrel with such force as to bring all parts of

the metal into equal strain at the instant of firing, according to Professor Barlow's formula. The ribs are curved in both directions, from front to rear, and from the inner barrel to the outer hoop or reinforce, so that they can spring enough to allow the inner barrel to expand both longitudinally, and the intention is, radially, by the heat of firing, *without straining the structure*. The ribs also yield, during the process of casting, under unequal contraction, due either to unequal cooling or the chemical difference in the metal. They are proposed to be *stiff enough to resist the pressure of the powder*, and sufficiently flexible to bend under the *greater force of expansion*—a force limited only by the ultimate strength of the metal. The elasticity of the whole structure would be greater than that of guns without ribs.

893. "This gun will undoubtedly cool without serious initial rupturing strains. The whole practice in founding, especially in founding car-wheels (which a cross-section of the gun resembles), *warrants this conclusion*. A plain disk wheel, not annealed, can only be stretched or compressed, and so broken or greatly strained in cooling, and therefore goes to pieces under service. A gun, when so corrugated as to bend in cooling at some thin part intended to be bent, instead of breaking or being severely strained at some part that cannot be bent, *endures more hard service than would be ordinarily expected of cast iron*.

894. "For the foregoing reasons, *the strongest iron may be employed*. It has already been shown that a *pure, high iron*, of *great tenacity*, shrinks too much to make a safe casting by other plans. *But car-wheels are cast as sound* from the *highest* and *strongest iron* as from a weaker iron, because ample provision is made for it to change its figure more or less, as required, without strain.

895. "Upon the proper tension and strength of the reinforce, as modified by its large diameter, the heat of firing and the elasticity of the parts within it depends, after all, the chief strength of the gun.

896. "Comparing the reinforce with an equal thickness of metal on the exterior of Captain Rodman's gun, the former is cooled on all sides to prevent, as far as possible, unequal shrinkage, and is carried in two directions to prevent unequal and injurious strain due to what unequal shrinkage there may be. The latter is cooled (in practice) only from the inside, so that its exterior surface is strained and weakened. It appears, then, that the former would be in a better condition to stand the tension, in which case, too, the tension can be the better regulated.

897. "The official report already quoted (376) is evidence that the outer part of the Rodman gun is drawn into *compression* by the subsequent shrinkage of the intermediate metal. It cannot be put into the desired tension except by cooling the gun exclusively from within; and this can only be done by keeping the mould at a temperature of 2700°—a process so difficult that it has not been realized in practice. But there is nothing to draw the corresponding part of the Wiard gun—the reinforce—into compression. All the parts inclosed by it have already cooled and set.

898. "In other words, the part that cools last regulates the strain of the rest. The interior and the exterior parts of the walls of the Rodman gun cool independently, and without any great strain; then the intermediate metal cools and puts strains into them which are just opposite to those required. But the reinforce of the Wiard gun cools last, and if it shrinks most, must compress the inner tube, and be itself drawn into tension—*the required condition*.

899. "As to the strain due to expansion by the heat of firing, suppose the reinforce and the barrel to be put under such respective initial tension and compression that the force of the powder would strain them equally and as much as they would safely be in service; if the ribs yield under the pressure of the powder, the barrel may be stretched to the breaking point before the reinforce is stretched to the same point. If the ribs do not yield under the pressure of the powder, then they will not yield under an equal pressure from the expansion of the barrel by heat, up to a pressure equal to the pressure of the powder—will act directly to stretch the reinforce, which had already been stretched as much as it will bear. Up to this point the case is similar to that of a solid gun. Beyond a pressure equal to that of the powder, *the ribs may yield to the pressure by heat*, without straining the reinforce as much as it would be strained in a solid gun.

900. "But the barrel will not be heated as much as the corresponding part of a solid gun, because it is *exposed to the air on both sides*, and presents a large radiating surface. Besides, the longitudinal expansion of the barrel is the source of the greatest strain, and this, in the Wiard gun, is *provided for by the longitudinal corrugation of the ribs*.

901. "The largest diameter of the reinforce is not a source of comparative weakness.

902. "On the whole, it is probable that the barrel and ribs of Mr. Wiard's gun can be cast without serious strains; that the reinforce can be shrunk upon them with some degree of tension; *that the strongest iron can be used;* and that the guns will not be seriously strained by heat. *The failure of the first guns, if they should fail, ought to be attributed to the improper carrying out of the principles; for the present knowledge on the subject of cast iron, however imperfect it may be, defines these principles with much clearness.*

903. That I should have received a contract to make this gun was a most alarming fact for the ordnance ring, and when the first gun came to be fired a doctored charge of powder was prepared for it, and it burst.

904. The projectile seen on the cut, Fig. 17, was a double one; that is, two projectiles cast together something like a "dumb bell." It weighed 900 pounds. When inserted into the gun its length was 23⅜ inches. It was not centered or supported centrally in the bore as it ought to have been, but lay in contact with the bottom of the bore; all the windage at the top. The powder charge was 80 pounds, only delivered from the magazine a few moments before the gun fired at dusk in the evening. The Assistant Chief of Ordnance, Navy, boasted that he would furnish a charge of powder that would burst the gun, and it did. When the projectile was recovered from the sand butt, which it penetrated only a few feet, it was found to be upset or reduced in length ¾ of an inch, or to 22⅝ inches. A burnished spot or band, reaching nearly all round, was found four inches wide on the rounded surface of its rear half, and a corresponding indentation was found at part of the bore, where it lay in front of the powder cartridge. This indentation was four inches wide and ⅛ of an inch deep, extending nearly around the bore to the top. I caused a like indentation of a surface 1 inch square in the surface of the bore of one of the fragments near the place where the indentation was made by the projectile, and the force required to force down the indenting tool was found to be 40,000 pounds to the square inch. The estimated average for that depth of indentation was 80 square inches which $80 \times 40{,}000 = 3{,}200{,}000$ pounds. This misdirected force was alone quite sufficient to burst the gun. When I arrived at that conclusion, I proceeded, with the full knowledge of the department, to make a second trial gun, as was plainly provided for in my contract, and I made preparation for securing a less severe charge of powder, also for centering the projectile in the bore. When the second gun was finished and reported ready for proof, I received a telegram from Washington, from the same Assistant Chief of Ordnance that supplied the doctored powder, informing me that my contract was annulled. This experiment cost me about $70,000, no part of which has ever been repaid, but I learned the necessity of centering projectiles in the bore of guns, which forms an essential feature in all my later inventions. My contract provided for rapid firing, for twenty rounds, after the first heavy proof-charge, which, it is believed, this first or the second gun could have withstood with centered projectiles better than any other gun ever made. I have since, however, developed plans which, by the use of centered mechanically-fitting projectiles, create but little friction, and which, being cen-

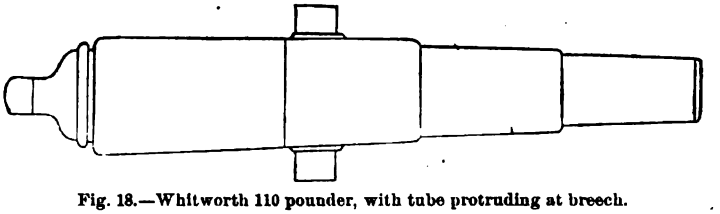


Fig. 18.—Whitworth 110 pounder, with tube protruding at breech.

tered, do not come in contact with the surface of the bore at any time while being inserted or ejected from the gun, and which do not permanently change their form in the gun. These enable me to utilize guns on hand, and render it unnecessary to provide for avoiding the effects

of unequal heating otherwise (see paragraphs 702, 708, 709, 710, 711, 712, pages 136 and 137), and leave nothing further to be desired.

905. During the bombardment of Fort Sumter, two Whitworth 110-pounders were disabled, as may be learned from the report of General Gilmore.

906. The inner steel lining tube slipped slowly back, and protruded one inch, as shown on the cut, Fig 18. A remedy for this was proposed by General Gilmore, viz, to screw on the reinforce bands hot, and thereby prevent the tube from slipping within the bands.

907. The first Armstrong 300-pounder built up with a tube and bands was of this kind, except that the breech piece was screwed in and abutted against the end of the tube.

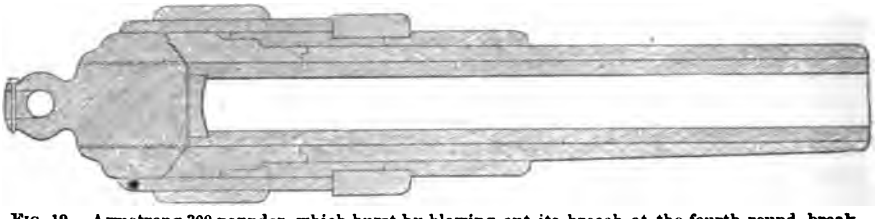


FIG. 19.—Armstrong 300-pounder, which burst by blowing out its breech at the fourth round, breaking out the reinforce band at its strongest part.

908. This is an example of the futility of attempting to restrain the expansion of metals by heat *in all directions*.

909. Metals expand and contract by increase or decrease of temperature with exactly the same force as that with which the same metals resist extension or compression to the same extent at the same normal temperature. Therefore with a rate of force which bears a close relation to their specific densities, permanent elasticities, and ductilities, when a cube (or any form of body) made of metal becomes subject to increase of temperature it expands heightwise, widthwise, and lengthwise to a known extent (for the common metals used in fabrication of guns). For instance, the rate of expansion of a cast-iron cube is for increase of temperature equal to 80° Fah. within temperatures and changes to which the common atmosphere is subject. The rate of expansion in all directions is one 5000th of its dimensions—height, width, and length.

910. If it be restrained from expanding in two of these directions, as is the tube or lining of a built-up gun which has strong bands shrunk upon its exterior, when it is heated it will extend in the one direction of least resistance three time as much as if it was permitted to expand in three directions, as it naturally endeavors to do.

911. In the English gun, shown in the cut No. 19, the tube was first compressed heightwise and widthwise by shrinking on the bands. A breech-block, as shown by the cut, Fig. 19, was then screwed in by screw-threads cut within the principal reinforce band and firmly abutted against the rear end of the tube. [The gun was then ready for an experiment to determine which of the three directions the expanding force resulting from afterwards heating the tube, while all the outside metal remained colder, and thus with a lower rate of expansion.] The experiment, which was conducted by making a sudden fire in the chamber of the gun (igniting the powder charge), and creating a sudden and extremely high expansive force between the walls of the gun and a heavy wedging, upsetting, jamming, and balloting projectile, grinding against the inner surface of the tube, and by its friction, in addition to the effect of the high temperature of the gases, suddenly raising the temperature of the tube and

suddenly expanding it.—The result was that it was proved that the least resistance to the expansion of the tube was lengthwise, and, assisted by the pressure of the powder gases, it blew the breech out, breaking the principal reinforce band in its *per se* strongest part.

912. I said lately, in giving testimony before a committee of the Senate:

913. "It is supposed that the rifling weakens a gun greatly; but it is well known to persons in the habit of estimating the strength of cylinders subject to an elastic pressure from within, that any tube closed at the ends and subjected to elastic pressure from within has twice the strength to resist transverse rupture that it has to resist longitudinal rupture. If it should burst, it would naturally by elastic pressure split lengthwise. If the groove of the gun was lengthwise and parallel with the axis of the bore, it would weaken it; but as it goes across the axis in a spiral around the outside, it is nowhere any great distance lengthwise of the gun in the parallel of the axis to the bore. Consequently it affects the gun very little."

914. The very gun under consideration, if made of one homogeneous piece of steel, and subjected to hydraulic pressure from within, would split longitudinally with one-half the force which would be required to break it across transversely, as this gun, Fig. 19, did break. An example

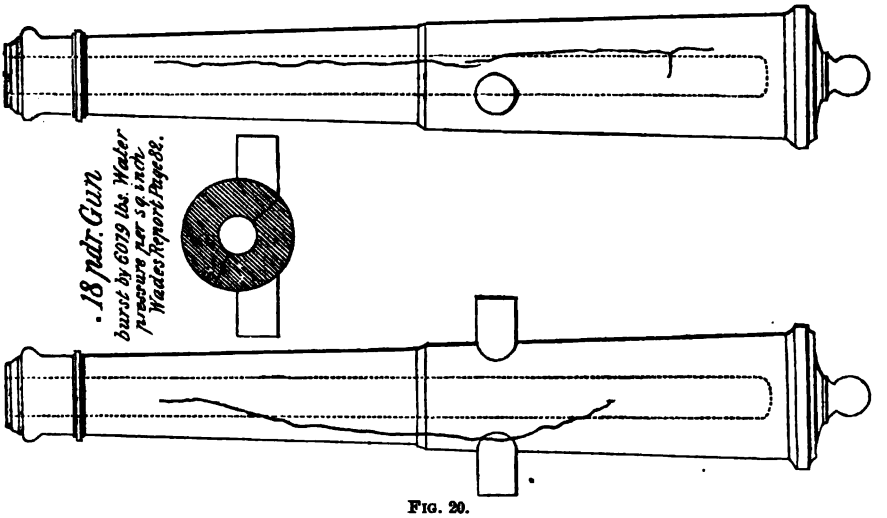


FIG. 20.

is found in the reports of Major Wade, Fig. 20, in a gun burst by water pressure. This gun, made of homogeneous metal, *i. e.*, metal without flaws or lines of weakness on account of welds or like defects, split longitudinally. Another example is taken from Rodman's reports. This

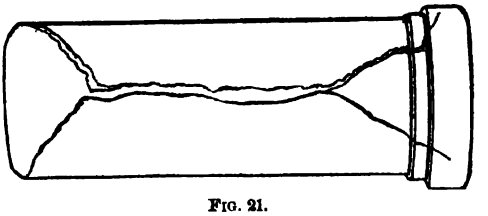


FIG. 21.

was one (Fig. 21) of a number of experimental hollow cylinders burst by water pressure. All followed the rule I have laid down, and split longitudinally.

915. The line of fracture on this cylinder, Fig. 21, branching off to either side, bears a remarkable resemblance to the theoretical diagram in Rodman's reports (page 47), copied in my essay on the bursting of guns, quoted in this paper from Holley's Ordnance and Armor, cut No. 8 of that series; in neither of these cuts, No. 8 and No. 21, is there any suggestion of the fact that all columbiads and other cast-iron guns cast hollow or solid have ruptured longitudinally not only along the bore, but the fracture has continued through the breech and cascabel, and thus affords a strong argument in favor of the unequal expansion theory.

916. The following are examples: The first and most striking one, Fig. 22, is copied from Wade's reports, and may be found facing page 64. This was an 8-inch columbiad, cast solid, which burst under rapid firing with unstrapped and uncentered projectiles.

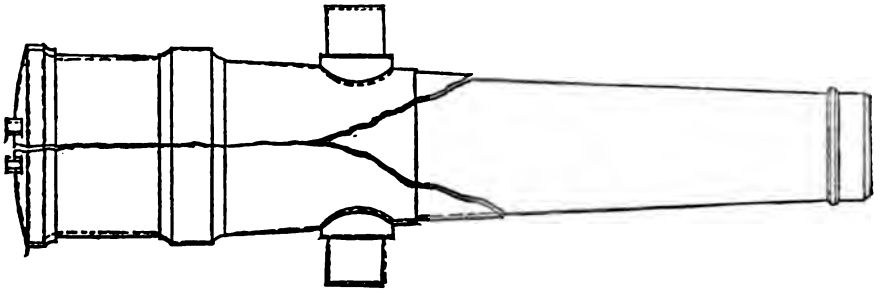


FIG. 22.—8-inch columbiad.

917. In Major Wade's reports may be found diagrams showing the lines of fracture of 16 guns which have burst; all but two show that the fracture extended through the breech and cascabel, the same in effect as Fig. 22. *The two exceptions were of guns burst by water pressure* alone. (Fig. 20, *ante*.)

918. On page 125, Rodman's reports, we are informed that "the cascabel dropped off" two of the guns then undergoing test, but it appears that this did not interfere with the progress of the experiments, and he says, "All the trunnions of both guns are slightly cracked at the junctions of the guns and rim-bases, the left trunnion of the hollow (cast) gun apparently the worst. Now these guns were not mounted on carriages for the trial, but were slung by chains from a pendulum frame; consequently there was no part of the force of the pressure acting to cause the cascabels to drop off or the trunnions to crack at their junction with the body of the gun. These parts were exposed fully to the cooling influence of the atmosphere, and did not respond to the invitation to expand with the body of the gun, as it was heated from the interior by firing.

919. Captain Rodman informs us, page 131 of his reports, that "the guns of 1857" were of the "old model," while "those of 1858 were of the new model," * * * "with increased thickness of metal in the breech, being over one and a half calibers [over 15 inches] thick in that part." We find among the plates illustrating the report of the Joint Committee on Ordnance, Senate, report committee No. 266, Fortieth Congress, third session, Plate IV, with figures showing the model of the 13-inch Rodman gun, like Fig. 23, and the line of fracture of the gun after it burst, notwithstanding the increase of thickness in that part, the fracture extended through the breech and cascabel. In fact

every columbiad of old or new model, and every Rodman gun, except a few disabled at the muzzle by the balloting of uncentered projectiles, has broken through the breech, the strongest part of the gun, the

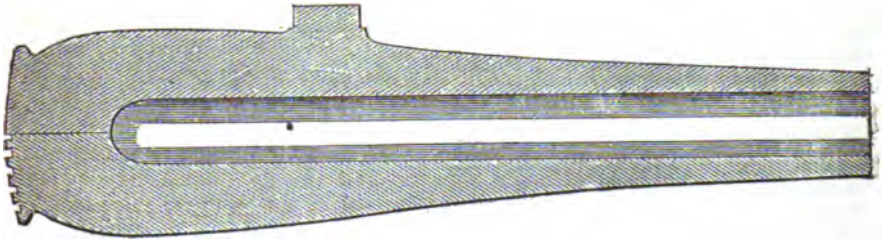


FIG. 23.

part least affected by the direct pressure of the gases of gunpowder. Admiral Dahlgren adopted in his designs even greater thickness of metal through the breech. A large number of these guns were made,

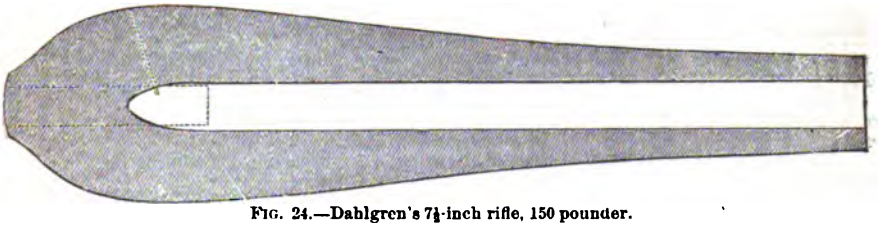


FIG. 24.—Dahlgren's 7¼-inch rifle, 150 pounder.

but as they were used with uncentered and expanding projectiles, they were abandoned; not one of them was ever put into use.

920. The Joint Committee on Ordnance referred to these guns in the following paragraph, page 217, S. Rep. Com. 266, Fortieth Congress, third session:

921. "Of four Dahlgren 150-pounder rifles one burst at the 27th fire, one at the 20th fire, one at the 75th fire, and one at the 60th fire."

922. And in relation to these the Admiral said, page 144, *Ibid.*, December 24, 1868:

923. "The mode of proceeding in proof or experiment with these guns has not been such, owing to the pressure of circumstances, as to furnish the means of replying accurately in regard to the endurance of these rifled cannon.

924. "Some of the guns of different systems have exhibited endurance under fire that would satisfy any requirement of naval service; and others of the same kind have proved so inferior as to destroy confidence.

925. "It must be kept in view that a *uniform endurance with service charges is the great desideratum, even though it be moderate.* This cannot be supplied by the excessive endurance of some pieces *if others fall very low.*

926. "To the last paragraph of this interrogatory, I would say that *this bureau is not cognizant of any rifled cannon of heavy caliber whose admitted character would warrant its being adopted for the ordnance of our Navy.*"

927. In the report of the Chief of Ordnance, 1865, was found the following evidence of misplaced confidence:

928. "Believing that, with our present knowledge of the properties of metals and our skill in working them, reliable rifle guns of large caliber can be made of cast iron, I have, with your sanction, caused a pair of 8-inch rifle guns of the supposed proper model and weight to be made. These guns are now at Fort Monroe, undergoing extreme proof, and should their endurance be satisfactory it is proposed to have other guns like them made."

929. No. 1 of this pair of guns burst at the 80th round, No. 2 burst December 4, 1865, at the 1,047th round; neither of these guns were fired rapidly. They were cast hollow after the Rodman plan. They were tested with expanding projectiles of the Dyer pattern, which had a sabot of lead to expand into the grooves and wedge between the ridged body of the projectile and the surface of the bore. It required but little interior heating to complete the rupture of these guns already strained just to the point of bursting, from being cooled from the interior when new; cast-iron guns are liable to rupture from such tensions. The following is from the report of the Joint Committee on Ordnance, S., page 266, Fortieth Congress, third session:

"SPONTANEOUS RUPTURE.

939. "Navy 11-inch Dahlgren gun found cracked at Reading foundry, before the turning was completed, November 10, 1862.

931. "Navy 11-inch Dahlgren gun cracked before the turning was completed, November 16, 1862, at Reading foundry, Pennsylvania.

932. "Navy 11-inch Dahlgren gun cracked previous to its completion at Reading foundry, November 16, 1862.

933. "NOTE.—The inspector gravely attributed the premature rupture of these guns to the swelling of the *sand* of the mold by heat.

934. "Navy gun 15-inch (no number and no date), burst *while cooling*, at the Fort Pitt foundry.

935. "Army 15-inch Rodman gun, No. 404, made at Reading foundry, burst open nearly the whole length while in the lathe. The explosion of this great gun was attended with a loud report equal to a six-pounder gun.

936. "Army 15-inch Rodman gun, No. 419, cast at Reading, Pa., burst in the pit after the removal of the core barrel.

937. "Army 15-inch Rodman gun burst in the pit at the Pittsburgh foundry, having split the whole length.

938. "Navy 15-inch gun, No. 25, sold at auction for cracks in the vent, 9th fire.

939. "Navy 15-inch gun, No. 26, sold at auction for cavities in the chamber, 9th fire."

940. It can be seen that solid cast guns are liable also to rupture from unequal cooling when new. This tension is however relaxed by age, as shown in a previous paper.

941. This relaxation of tensions by age is illustrated by the familiar example of the barrel made of staves, bent when new by the cooper, who drives on the hoops to bend and warp them into constrained positions. If the hoops should be removed soon after, the staves would recover their original form had before they were assembled into the barrel. But these tensions relax with age, and if after waiting a few years—the staves would be annealed meantime—and upon removing the hoops it would require as much, in fact much more, force to return them to their original form than was at first required to bend them from it.

942. The glaciers are rivers of ice flowing down the incline of mountain gorges with a continued slow current, more rapid in the middle of the stream than at its edges, where it is obstructed by the protuberances of the banks. These expand out into lakes, where the current also slows, and contract again in the narrow gorges with a relatively quicker flow. The flow of solids has only received attention from *savants* during later years. Even the most rigid tempered steel will relax its tensions with age, the compressed parts flowing, but with extreme slowness—the sloth and the snail move with railroad speed as compared with its velocity—toward the parts extended with even no greater variations of temperature than those that succeed from night to day, or winter and summer.

943. The false reports emanating from our ordnance bureaus have done

more to establish confidence in the endurance of cannon than has been justified by the real results. The following is an example:

[From the report of the Chief of Ordnance, War Department, for 1866.]

944. "The experiments which have been carried on at Fort Monroe arsenal to test the power and endurance of the 8-inch and 12-inch rifle guns, made of cast iron, by this department, are highly satisfactory, and warrant the belief that cast-iron rifle guns, of these calibers, may be introduced into the military service with safety and advantage. The 12-inch rifle, throwing a projectile of 600 pounds, and with 55 pounds of powder, has been fired 390 times. It is believed that no rifle gun of this caliber has ever given so great endurance. The further trial of these guns will be continued."

945. Before the facts become public, additional appropriations are always secured, and all improvement is ignored in the expenditures, which are diverted in the main to the emolument of the official members and the ordnance ring.

946. At the date of the report for 1866 only six cast-iron rifles, of 8-inch caliber or larger, had been made altogether by or under direction of the ordnance bureaus, War and Navy, of "cast iron," two of 8-inch caliber, and four of 12-inch caliber. The 8-inch guns had both burst, as before stated. Three of the others referred to in the 1866 report were tested with the following result (see page 143, S. Rep. Com. 266, Fortieth Congress, third session):

"12-INCH RIFLES.

947. "These were castings on the exterior form of 15-inch guns, bored to 12 inch and rifled. The order was given August 31, 1863, by Captain Wise, then chief of bureau. One of these was rifled on Mr. Parrott's plan, one on Atwater's, and one on Rodman's.

948. "The 12-inch, rifled on Mr. Parrott's methods, burst at the 27th fire, viz:

949. "Five charges of 35 pounds of mammoth powder; five charges of 40 pounds of mammoth powder; five charges of 45 pounds of mammoth powder; *five charges of 50 pounds of mammoth powder;* five charges of 35 pounds of No. 7 cannon powder; one charge of 40 pounds of No. 7 cannon powder; three charges of 45 pounds of No. 7 cannon powder.

950. "The 12-inch gun, rifled on General Rodman's method, was badly cracked by 16 fires, viz:

951. "Three charges of mammoth powder, 35 pounds; three charges of mammoth powder, 40 pounds; four charges of mammoth powder, 45 pounds; *four charges of mammoth powder, 50 pounds;* one charge of mammoth powder, 35 pounds; one charge of mammoth powder, 40 pounds.

952. "Shot, 618 to 619 pounds. Gun cracked; firing stopped.

953. "The third 12-inch, rifled on Atwater's plan, burst at the 30th fire; *generally 55-pound charges*; and shot varying from 416 to 535 pounds.

954. "The practice was conducted at Fort Monroe by the Army ordnance (1867)."

955. The fourth 12-inch gun referred to in the 1866 report burst soon after the report was made (and it has been suggested even before the report which commended it so highly was printed); another 12-inch rifle, made under the direct supervision of General Rodman, was disabled at the second round at Fort Delaware during the firing at iron targets. The charge was 100 pounds of very dense large-grained mammoth powder specially prepared for the trial. But it is to be noticed that the first three guns burst with charges only half as great, the heaviest in the gun rifled on Atwater's plan—55 pounds—the greatest endurance with the three extended only to the 30th round. There was a pretense that these guns were Navy guns, but cast on the Rodman plan, and that they were turned over for trial and proof to the War Department. The Navy Department did not report their bursting because they were burst by the Army Ordnance Department. The Army Ordnance Department did not report their bursting because they were made *for* the Navy Department.

956. This fact, however, did not "warrant the belief that cast-iron rifles of these calibers may be introduced into the military service with safety and advantage."

957. When the chairman of the Joint Committee on Ordnance had the above facts brought to his attention, he exclaimed: "Safety to what, and advantage of whom?"

958. In the falsity of character and purpose, the report of the Chief of Ordnance, General Dyer, for 1866, finds its counterpart in the report of the Chief of Ordnance, General Benét, for 1878, from which the following is quoted:

959. "The important tests of the 8-inch breech-loading rifle, converted from a 10-inch smooth-bore gun, and mentioned as completed under proof, in my last report, are still in progress, and up to date 202 rounds (190 with full battering charges) have been successfully completed. The endurance so far has proved satisfactory, and no evidences of want of endurance in its special construction have been so far afforded; and we have good grounds for the opinion that it will stand its thorough proof, and establish the fact that we can convert, after this system, our original smooth-bore cast-iron guns into breech-loaders, *or produce original breech-loading cannon of the heaviest construction*, using in a short time wholly the products of our *own* founderies and other manufacturing establishments."

960. Notwithstanding the endurance had proved so satisfactory, the second of the lined guns—it was shown by the report of the same Officer for 1876—had burst, and in his report of 1878, page 9, the Chief of Ordnance, General Benét, said of the coils:

961. "Defective welds in the coils are the only elements of weakness, but these defects are grave, as it is impossible always to detect them in the manufacture of the tubes. The *dragging effect of the shot*, as it passes through the bore, under the great propelling force of the powder, *is liable to pull the tube apart at a defective weld and disable the gun.*"

962. In the same report, Colonel Crispin said, page 351:

963. "The difficulties of securing perfect weldings in coiled wrought-iron tubes have led, in some instances in the history of the employment of linings, * * * *to the development of grave accidents in service* (?), tubes being blown out and the muzzles torn off, all from defective welds."

964. Coiled wrought-iron tubes being the essential feature of all guns recommended for conversion or construction from 1874 to the present time.

965. General Benét appeared before the Senate Subcommittee on Appropriations January, 1881, to advocate a second appropriation of $400,000 for Crispin patent guns lined with coiled welded tubes. Mr. Hunt, the maker of the guns, also testified before the committee, highly recommending them, as lined with a coiled welded tube. Well, the guns burst. Then Mr. Hunt, under the excitement of the suspension of the South Boston Iron Company, made a most contrite confession, as follows:

[Boston Herald interview with Mr. William P. Hunt, president South Boston Iron Company, November 20, 1881.]

966. "We made a 12-inch breech-loading cannon, and an 8-inch one. They were made after what is known as the Crispin design. * * * We used the best imported steel for the work that was obtainable. The rifled tube made of wrought iron. And yet, when the 12-inch gun was taken to the proving grounds at Sandy Hook, after the firing of only a few rounds, the steel breech broke off at its thickest part and blew out. The 8-inch gun made in the same way also broke, and its breech blew out after firing a few rounds. This method of gun-making is a very expensive one, the steel breech costing enormously. * * * The coiled wrought-iron tube is about the worst form to employ, since it is not only altogether deficient in transverse strength, but has a welded spiral line of over 100 feet exposed to the action of the discharge. * * * That the employment of a coiled wrought-iron tube within a heavy steel * * *

casting is a combination without justification, and does violence to the well-known physical properties and characteristics of the metals thus combined. * * * A series of ominous incidents have occurred in the gun tests. The more or less free opening of welds in every gun tested, and the demoralization of the material at the seat of the charge; the cracking from breech to muzzle of the steel tube and jacket in one of the early converted guns, * * * the blowing out of the tube of the 10-inch heavy muzzle-loading rifle at the fourth or fifth fire, through the opening of a defective weld, * * * to say nothing of the friction and the enormous power required to tear off the muzzle of the gun, the body of the gun sustaining no apparent injury; the discontinued proof of the new 12.25-inch rifle after 30 rounds, through fear of a similar accident; the complete cracking through, necessitating early repair, of the tube of the 11-inch breech-loading rifle near the seat of the gas check (this gun has since burst, after a few additional rounds, rupturing the steel by blowing out the breech, but without injury to the cast iron); * * * the destruction, a few days since, of the new 8-inch converted breech-loader by rupturing at the third fire the heavy steel jacket in its thickest part, the gun body, as usual, being unimpaired. Such a series of accidents or failures cannot certainly by any ingenuity of reasoning be interpreted as complimentary to either the steel or the wrought iron, separately or in combination." * * *

967. In my letter written to the Secretary of War, the Hon. Alexander Ramsey, dated 27th July, 1880, three or four months before the contract was awarded to the South Boston Iron Company for the Crispin 12-inch rifled guns lined with a coiled welded tube—without advertising—(at least no notice was given to me, although I had a proposal far more favorable—for the government—dated July 1, before the department).

968. I said, in relation to the guns converted on the Crispin plan, which have since been tested, and burst, as stated by Mr. Hunt:

969. "One of the merits claimed for the Rodman gun is that the mode of cooling insures a very dense quality of metal for the surface of the bore, in contradistinction to the solid mode of casting, which results in porous and spongy metal in the center of the cast block from which the gun is made, as in the Dahlgren gun.

970. "This spongy metal, it was claimed by Dahlgren, was removed in the process of boring. It is well known that there is a region of spongy, porous metal in the Rodman gun also in the middle of the mass, half way between the cooling surface where the liquid iron freezes last; *and the thicker the wall of the gun the more marked is the porosity.*

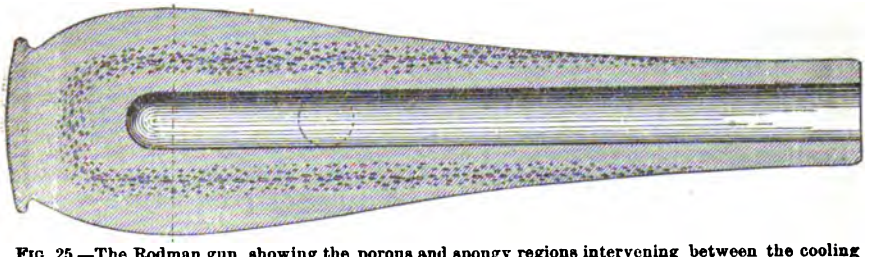


FIG. 25.—The Rodman gun, showing the porous and spongy regions intervening between the cooling surfaces.

971. "On an occasion, many years ago, when I was boring a Dahlgren gun at the Wiard Ordnance Works at Trenton, with an annular boring tool, I noticed this po-

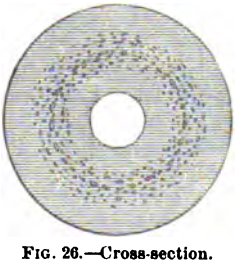


FIG. 26.—Cross-section.

rosity in one of the cores I had removed near the bottom of the bore, and having a common wrought-iron railroad spike at hand, I drove it with a common hand ham-

mer into the end of the core piece—which was about eight inches in diameter and thirty inches long—as easily as I could have driven it into an oak railroad tie, in fact its whole length, and deeper, so that I could hammer the soft, spongy cast iron down and completely cover the head of the spike." * * *

972. "In preparing the Rodman guns to receive the lining, as in process of conversion by lining with a tube, the bore has to be enlarged, and thereby the dense metal surrounding the bore is removed before the tube can be inserted. It is not expected that the tube *per se* is sufficiently strong to resist enlargement; if it is, there is no need for reinforcing it with a cast-iron jacket, and but little more utility in indeavoring to restrain its enlargement by the aid of a jacket which interposes only the spongy and porous iron between the exterior of the lining tube and the exterior shell of the cast-iron jacket."

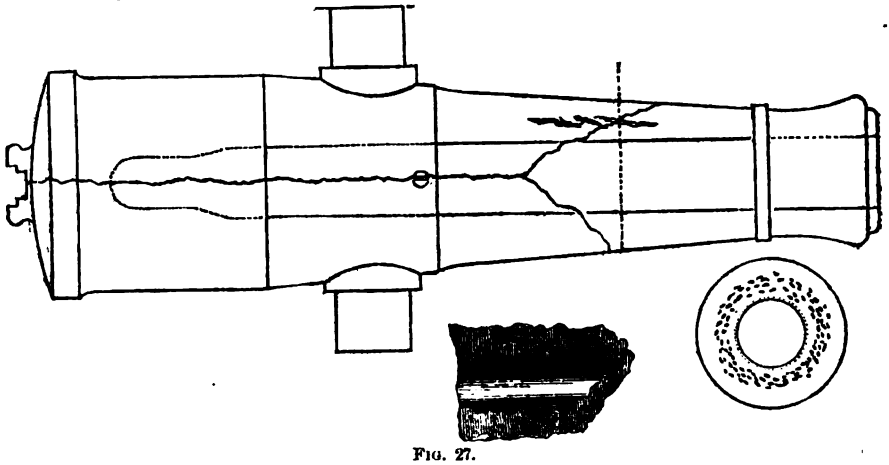


FIG. 27.

973. Fig. 27 is a reproduction of Plate VIII, from Major Wade's report, following page 192, showing actual fissures which were exposed when the gun burst.

974. In a foot-note to page 322, Holley's Ordnance and Armor, the effects of such shrinkages, the result of unequal cooling, are referred to, and the remedy, in part, applied by Admiral Dahlgren.

975. "In a discussion on guns, before the Franklin Institute (1862), Chief Engineer Wood said that 'Captain Dahlgren's method to obviate the evil (of strain due to unequal shrinkage) consisted in casting the gun more nearly in the form of a cylinder, then turning off the additional metal on the exterior which had caused the strain in unequal shrinkage by having been first cooled in the mold. His guns were cast solid; then the interior part, supposed to be the weakest, is bored out."—*Scientific American*, November 15, 1862.

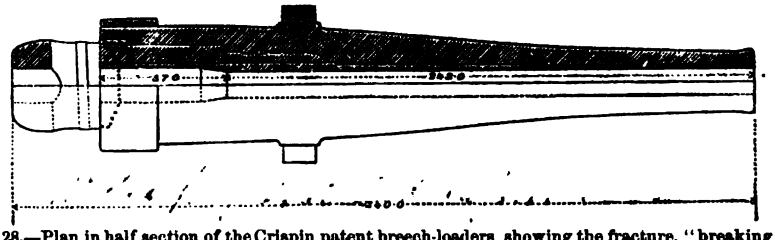


FIG. 28.—Plan in half section of the Crispin patent breech-loaders, showing the fracture, "breaking the steel in its strongest part."

976. Rodman afterwards followed Dahlgren's plan in allowing more metal along the chase, afterwards to be turned off; but while the evil was ameliorated thereby, it was not corrected for the muzzle-loading guns.

977. In inserting the thicker reinforce jacket for the breech-block receiver of guns converted to breech-loaders, the spongy metal was mostly removed, as well as in the new constructions, in all of which the heavy steel reinforce was screwed into the cast-iron jacket while it was heated for the purpose and expanded. (See cut Fig. 28.)

978. When the guns burst, Mr. Hunt, who, like the Squire of Hudibras—

"Could foretell whatever was,
By consequence, to come to pass,"

said, in his Boston Herald interview:

979. "We used the best imported steel for the work that was obtainable. The rifled tube was made of wrought iron. And yet, when the 12-inch gun was taken to the proving grounds at Sandy Hook, after the firing of only a few rounds *the steel breech broke off at its thickest part and blew out.* The 8-inch gun, made in the same way, also broke, and its breech blew out after firing a few rounds.

980. *"The employment of a coiled wrought-iron tube within a heavy steel * * * casting is a combination without justification, and does violence to the well-known physical properties and characteristics of the metals thus combined."* * * *

981. The following is a further quotation from my letter of 27th July, 1880:

982. "In inserting the thicker reinforced jacket required to support the fermature of the breech-loading gun, the error of the procedure in converting cast-iron Rodman guns is much magnified, and the larger the caliber the worse the result to be expected.

983. "There is another difficulty which will be encountered in time by our ordnance authorities or by artillerists in using *breech-loading guns lined with a tube,* if such guns should be adopted for service without having had the test of battle applied, *i. e.*, the crucial test of rapid firing before a system is adopted for mounting in the fortifications in large numbers.

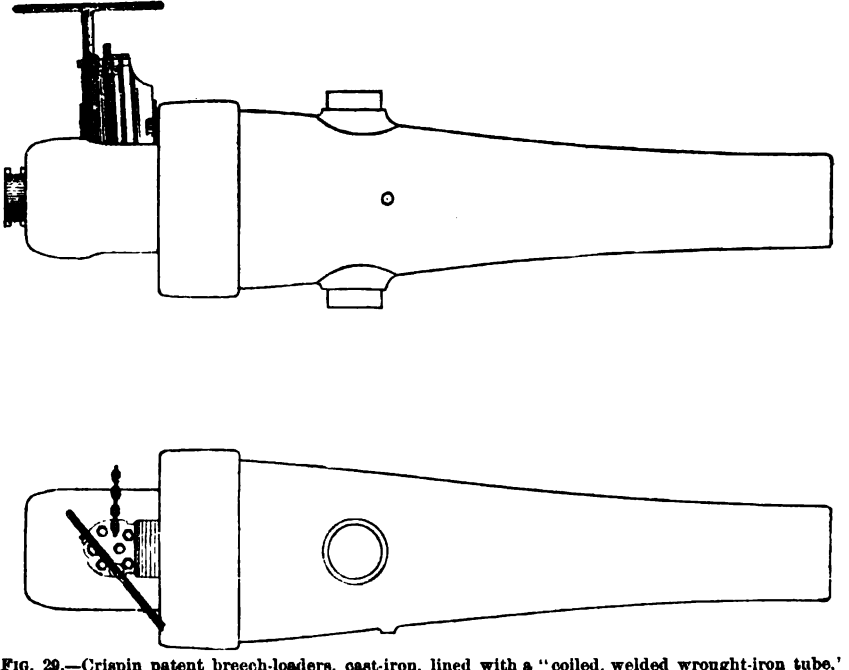


FIG. 29.—Crispin patent breech-loaders, cast-iron, lined with a "coiled, welded wrought-iron tube,' "and that within a heavy steel reinforce."

984. "After the expenditure of thirteen millions of dollars in the development of the Armstrong system of breech-loading guns, lined with a tube (in England), all the guns were cast aside as worthless—not so much because they burst, as many did,

although made of the strongest material and in the most skillful manner, as because, whenever any gun of the kind, if of *large caliber*, was fired three or four rounds in quick succession, *the inner tube would expand lengthwise and jam the breech-block so firmly that the gunners would have to wait three or four hours before it could be removed;* and it frequently happened, upon the bursting of a great gun of this kind, that *the direction of the line of fracture bore plain evidence that the lengthwise expansion of the inner tube was the sole cause,* as in the case illustrated by the following diagrams, taken from the report of the Joint Committee on Ordnance." (See Rep. Com., S., 266, Fortieth Congress, third session, Plate X. (Figs. 18 and 19 *ante.*)

985. Among the papers I laid before the Ordnance Board of 1872, Colonel Crispin and General Getty being members, was the following, page 79 of its report:

THE ORDNANCE PROBLEM IN ENGLAND.

[From the Naval and Military Gazette.]

986. "It is not known what direction Mr. Gregory's motion as to cast-iron guns is to take, but if it arouses a discussion on the endurance of heavy ordnance, much good may flow from it. Some persons assert that the war office is fully aware that the maximum amount of work is not got out of the material employed (? N. W.) but it is reluctant to embark once more upon competitive trials. These add that tens of thousands are being yearly expended in a system of rifling which, as regards heavier guns, limits their endurance to slow firing (? N. W.), with intervals of weeks between every few rounds, and even then admits only 100 (? N. W.) discharges from 25-ton guns, with reduced charges of pebble-powder. The admiralty have had their attention called to the fact that the whole offensive powers of the Glatton are dependent upon the life of two of these guns; and as naval warfare demands continuous and quick firing, it is proposed to try whether one of the Glatton guns will endure a whole day's practice, firing 100 rounds at a target, with several degrees of elevation. This may set at rest an important point which has never been settled, viz: Whether ships armed with 25-ton guns would not be disarmed by their own projectiles in the midst of an ordinary naval action.

987. "*Ibid.*, *May* 18.—The alarm felt on board the Bellerophon as to the disintegration of the 14½-ton guns while firing at targets in the Atlantic appears to have been a little exaggerated. It is quite true that the inner steel tubes have in three cases protruded (? N. W.) themselves outside the muzzles; but this is probably due to the setting home of the outer coils. And it is also true that in two other guns the outer coil presents openings between them in a direction transverse to the bore (? N. W.), the separation in one case being 1 foot and in the other case 2½ feet from the muzzle. These separations occur just over where the accelerating spiral brings the greatest strain upon the rifling (? N. W.). But it is questionable whether either of the guns is really disabled. To the nautical eye, such cracks are not reassuring. No doubt the guns would be better without them.

988. "There is, as most officers are aware, 'a cemetery of suicides' in the royal arsenal, to which heavy guns are consigned which have destroyed themselves under fire. Many additions have been made to this cemetery since the parliamentary returns of 1866, but we are without exact details as to the manner in which these more recent suicides destroyed themselves. The time seems, however, to have arrived when a further parliamentary return might be fairly given, showing what guns have been temporarily or permanently injured or disabled by firing since the introduction of the present system of rifling in 1865; the nature, position, and cause of the injuries; whether they necessitated any cessation of firing, and, if so, for how long; and whether the repairs were effected in the battery or ships, or after removal to the royal arsenal. To show that there is plenty of material for a somewhat lengthy return, we append a few examples which have come under our own notice; remarking that the list does not pretend to absolute correctness, and that it only refers to the home station, and does not include the injuries, whether temporary or permanent, inflicted by the wabbling, hammering, wriggling projectiles in their efforts to escape from guns fired on foreign stations. The general testimony of naval men that their projectiles almost invariably make an intermittent puffing noise in the air, and display a remarkable waltzing action in their flight, and not unfrequently break up in escaping from the gun, together with the incipient abrasions discovered in the Monarch's 25-ton guns, after an *average of only thirty-five rounds*, warrants the assumption that the above list is a very small moiety of the injured guns which the admiralty could produce, if required to do so.

989. "A few years ago a 9-inch gun burst violently on board the Russian frigate Alexandra Nwsgi, in the Baltic, killing twelve officers and men, and wounding thirty

persons, and seriously damaging the ship. This explosive burst was, at the time, attributed to the gun being made of block-steel; but the most cursory view of the 'cemetery of suicides' at the royal arsenal will show that this is not the only material liable to such fearful explosions. Whenever a projectile jams in its exit from a gun, with a heavy charge behind, it matters not what material it is made of, an explosion must take place. Several wrought-iron coil guns, as well as converted guns, and rifled cast-iron guns, have had studded shot wedged in their bore while firing, with consequences only not like that of the Alexandra Nwsgi because the guns' crew were hid away behind traverses and other safe retreats. We have not included in our list those explosive bursts which occurred to guns rifled on the various abandoned Armstrong systems. But we may mention the jamming of a lead-coated shot in a breech-loading Armstrong-coil gun, 40-pounder, and the jamming of a studded projectile in a 9.22 inch Armstrong-coil Hurst gun, as instances of explosive burst under those systems. The fearful explosion of the converted 7-inch 68-pounder of ninety-five hundred-weight into seventy-six pieces, which were flung over an area of 580 yards by 150 yards, mentioned below, was similarly due to the wriggling projectile being unable to get out of the gun, and not to the material, faulty as we conceive it to be, of the converted gun. Such an explosion may always be expected whenever the pieces of a broken projectile wedge themselves in a heavy gun, whatever material it be made of. Even the improved Armstrong or Frazer-built gun cannot withstand such a wedge as was seen in the case of an explosive burst of a 12½-ton gun in 1868, and in others now in the 'cemetery of suicides,' the particulars of which have not reached us.

990. "Whenever a studded projectile breaks up in a gun through its stud-holes, it is a mere accident that the broken pieces do not wedge themselves in the bore across the spirals, and the wonder is not that 'the most magnificent guns in the world' are occasionally exploded by the wedging of broken or studded projectiles, but that they escape explosion so frequently, and are only disabled temporarily or permanently, or otherwise injured by projectiles which so frequently break up in the bore. * * * We may shut our eyes like the ostrich by burying our heads in the sands of secrecy, or enjoy the silence of the official fool's paradise, but nothing is more certain than that the present system of rifling frequently causes projectiles to break up in the guns, that such projectiles have jammed in our guns, and that those guns have exploded with fearful violence.—(*Ibid.*)

THE ORDNANCE PROBLEM IN THE UNITED STATES.

991. "Question. Will you give a brief history of the endurance of these guns?

992. "Answer. The first 12-inch gun, the only one that has been proved to extremity, has been fired, I think, about 480 fires. * * * That gun burst, as was supposed, by the jamming and wedging of the projectile in the bore. * * *

993. "These guns have both been subjected to extraordinary pressures from the jamming and upsetting or breaking of the projectile inside of them.

994. "Question. Do ordnance officers all agree that the breaking or bursting of the projectile is the chief cause?

995. "Answer. No; not that it is the chief cause, for the reason that it ought not to occur, but that it is a potent cause when it does occur, especially the upsetting of the body of rifle projectiles.

996. "Question. * * * * Why is there no certainty of the cause?

997. "Answer. When a gun bursts, and you find the shot fired at that time to indicate jamming or wedging, or you see that it is broken, the presumption is, and I think as a rule a fair one, that that was the cause of the bursting of the gun at that round. * My belief is that, after we shall have procured a projectile that is as certain in its operation in the rifle-gun as the round shot is in the smooth-bore, we can, by firing to extremity one or two 12-inch guns, fix a limit within which the gun may be considered absolutely safe, but it will require experiment to fix that limit.

998. "It is more difficult to get a perfectly safe projectile for a large gun than for a small one."—(*Testimony of General Rodman before the Joint Committee on Ordnance.*)

999. The review of the Nut Island experiments shows that a projectile has been produced and tested which is as certain in its action in the rifle gun as the round shot is in the smooth-bore—a projectile which gets out of the gun with less frictional resistance than any other known or ever tested, and which is therefore less liable to heat the interior of the gun than any other known.

1000. The 15-inch rifles tested on Nut Island, therefore, did not burst, although fired with charges three times as great as the cast-iron rifles of 12-inch caliber above referred to (par. 956, 957, 959, 962).

1001. The Parrot gun made of cast iron and banded, when used with expanding projectiles burst during the war as often as they were used in service; at the combat with Fort Fisher every one of this kind used in the fleet burst on this occasion. They, in common with all the guns in the fleet, were fired rapidly—at the rate, it will be noticed, of "115 per minute."

[From the report of Rear-Admiral Porter of the first attack on Fort Fisher.]

1002. "One or two leading vessels having made the mistake of anchoring too far off, caused those coming after them to commit a like error; but when they all got into place and commenced work in earnest, the shower of shell (115 per minute) was irresistible. So quickly were the enemy's guns silenced that not an officer or man was injured. I regret, however, to have to report some severe casualties by the bursting of 100-pounder Parrott cannon.

1003. "One burst on board the Ticonderoga, killing six of the crew and wounding seven others. Another burst on board the Yantic, killing one officer and two men. Another on the Juniata, killing two officers and wounding and killing ten others. Another on the Mackinaw, killing one officer and wounding five others (men). Another on the Quaker City, wounding, I believe, two or three. Another on the Susquehanna, killing and wounding seven, I think.

1004. "The bursting of the guns (six in all) much disconcerted the crews of the vessels when the accident happened, and gave one and all a great distrust to the Parrott 100-pounders, and (as subsequent events proved) they were unfit for service, and calculated to kill more of our men than those of the enemy."

[From the report of Rear-Admiral Porter of the second attack on Fort Fisher.]

1005. "I believe we have bursted all the rifled guns left in the fleet—one on the Susquehanna, one on the Pequot, and one on the Osceola—and I think the reputation of these guns is now about ruined."

1006. Forty-six men were killed or wounded by the bursting of these guns, while only 11 were injured by shells from the enemy's guns.

1007. Some of these guns, but not many, exhibited fair endurance when fired slowly with small charges.

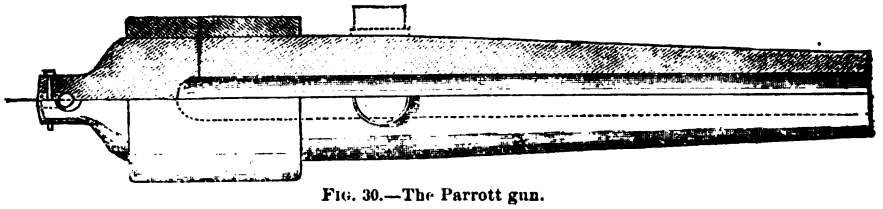


FIG. 30.—The Parrott gun.

1008. Diagrams accompanying the S. Rep. Com., 266, Fortieth Congress, third session, show that the breech blew out of a number of these guns with a fracture similar to Fig. 19, the Armstrong banded gun, and Fig. 28, the Crispin breech loader. The wall of cast iron under the band was too thick for the heat to extend through in rapid firing. If it had been thinner it would have merely slipped under the band, as shown in Fig. 18, the Whitworth. Other diagrams in the same report show a line of fracture similar to Fig. 3. The steel gun, Fig. 15; Figs. 22 and 27, cast-iron guns, heated unequally, by which the interior metal was extended longitudinally and tangentially.

1009. It was with one of this kind of guns, originally 8-inch caliber bored out to 9 inches and rifled (used throughout the experiments with 30 and 40 pound charges of powder, while the charge with which they burst in service was only 15 pounds), that the remarkable result was obtained of penetrating 16 inches of solid iron with a charge of 40 pounds of powder and a shot of 203 pounds' weight on Nut Island 22d November, 1875 (see "Review"); but the projectile was a mechanically fitting

one and centered, a shot which caused very little friction in the bore, while the expanding projectile would have required 1,000 times as much pressure to force it slowly through the bore.

1010. Whenever a fortification or a naval bill is pending the press teems with grandiloquent accounts of the wonderful achievements of German, English, and Italian guns. Not one of either of these kinds has ever been fired on the proving ground, a number of shots in succession, with such a rate of rapidity as would be necessary in battle, yet a number of each kind has been disabled or burst in experimental firing. It has already been shown in another paper that the whole battery of one of the English iron-clads was disabled at the bombardment at Alexandria and had to retire to Malta for a new armament. Several accidents have occurred to the Italian guns, Fig. 31. The Alexandra's battery (12 guns, 25 tons and 18 tons), were much smaller than these

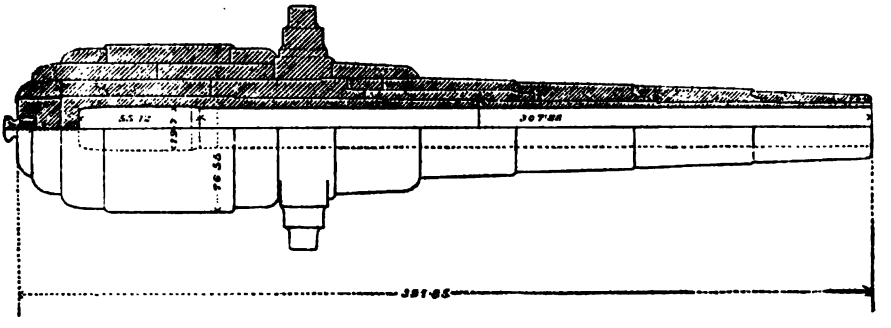


FIG. 31.—The 100-ton Armstrong gun.

and, as has been shown, "the larger the calber the less the endurance." One of the 81-ton guns was burst on the Thunderer, and many have had their bands separated, if they did not burst, so as to open the joints alarmingly by the lengthwise expansion of their inner tubes.

1011. The Krupp guns of larger caliber are fired sparingly. The maker will not sell a single one for experiment away from his own proving-ground, and the bursting of the Crispin guns, which were the same as the Krupp, except in the cast-iron jacket, which was uninjured, was an indication of what would happen to a Krupp of the same caliber if used with compressing projectile of the same kind with a brass sabot. The Krupp sabot is of softer metal, and his guns are not fired at any time three or more rounds in succession with intervals only sufficient for loading. One of the Crispin Krupps burst at the third round, the other at the eighteenth. Whenever we get the facts we find that there is a remarkable want of uniformity of results; but it is so seldom that more than one round is fired at one time under like conditions that an opportunity for comparison is not afforded, except to the persistent student.

[From the London Standard.]

1012. "A disappointment, which occurred in a second attempt to fire the 100-ton gun some days ago, whetted the interest in a renewal of the experiments yesterday. After an inspection of the gun, and a preliminary trial of the hydraulic machinery, the port door of the loading turret, technically called the 'cage,' was opened, and the muzzle of the gun depressed to the loading position. The proof-shot of 2,000 pounds weight was placed in the loading-truck, and the two cartridges were placed in position behind it. The powder charge was now increased to 441 pounds, and the powder was of the character professionally described as 'P 2,' which consists of cube-shaped 'pebbles,' one and one-quarter inches in diameter.

1013. "Loading was the work of a very few minutes. It was not performed as a time test, but it has been found that the whole operation of loading, elevating, training, aiming, and firing can be got through in less than two minutes. Of the 30 feet 3 inches, which is the depth of the bore, the charge occupies nearly 9 feet, and the mark on the hydraulic piston showing that it had gone fairly home, the muzzle was raised and trained to the left, the work of a very few moments, seeing that the gun can be carried completely round in 18 seconds. With the aid of ladders, Captain Morley, R. A., the proof officer, and his assistants, laid the gun so as to direct the projectile through the two electric screens which stand before the butts to measure the velocity, a wire from the instrument room was connected with the vent, and the warning bell was sounded. Then it was found that Colonel Inglis, R. E., who is president *pro tem.* of the committee, was to occupy the turret while the gun was fired, and after handing to Lieutenant Willocks an official-looking paper, which, by grim joke, was said to be his will, he entered the exposed side of the turret with a lighted lamp, and was fastened in with chain and staple. Major Ellis takes his stand beside the gun on the open side of the *emplacement*, and Captain Lewis, R. E., posts himself in the recess on the other side, where are the levers which control the machinery. All others withdraw to such distances and refuges as prudence may suggest, and, without any long interval of suspense, the gun is fired. As the spectators run forward they see Colonel Inglis walking out of the turret, the door of which has burst open, breaking the iron staple. He describes the concussion, however, as not distressing, and accounts for the door opening by the outside vacuum created by the expansion of the powder gases, which he thinks can hardly affect the permanent works, inclosed as they will be on all sides with heavy masonry. As a man will always have to occupy the turret to work the loading apparatus whenever the gun is in action, it was assuring to have the opinion of Colonel Inglis that he should be quite comfortable under the circumstances. The officers who stood by the gun, stated that the effect was much the same as they might experience fifty yards off, and the impression upon the other observers was that the report was not quite so loud as they had heard the other day. This impression was soon confirmed in various ways. The recoil with the increased charge was but 2 feet 8 inches, not much more than half the recoil of the other day; the shot, which then went 45 feet into the sandbank, was now found at a depth of 30 feet only; and, most conclusive of all, the velocity, which with the 425-pound charge was 1,520 feet per second, now measured, with the 441 pounds of powder, only 1,040 feet. It was clear that there was 'something wrong somewhere,' and the natural conclusion was that the projectile had slipped forward while the muzzle was depressed. The gun was therefore loaded again with the same charge of 441 pounds, care being first taken to wash it well out, and search it with a mirror for obstacles, of which none were found, and all being prepared it was once more fired. The report was sensibly heavier, the recoil was 4 feet 7½ inches, the penetration of the sand butt was 45 feet, and finally Captain Morley came from his observatory with a report of a velocity of 1,556 feet per second. As in this round the shot was proved to be in its proper position by a measuring-rod, after the gun was elevated—a precaution which was not observed in the previous round—the suspicion that the shot had slipped forward gained strength, and it will probably be requisite to employ wads in future experiments."

1014. The most remarkable point to be observed in this experiment, after the lame explanation of the cause of the differences in the velocity for the equal charges, is that the shot impelled by 425-pounds penetrated in one case only 2 feet further, and in the other case 10 feet less distance into the sand than the Wiard gun fired at Nut Island with only 70 pounds of powder; and if when it is surmised that the shot not being "home," or having an increased powder space behind it, accounts for the reduction of velocity, what becomes of the theory—and practice—of our ordnance authorities under which they make chambered guns—the chamber only to be partly filled with powder—in the expectation of obtaining increased velocity and force to the projectile without increasing the powder charge?

1015. My proposal laid before the committee contemplates chambers in breech-loading guns which are to be filled with powder in the expectation that increased velocity may be secured thereby from long-bored guns.

1016. By this method I expect to produce better results than are expected with an accelerating gun, by using the accelerating cartridges

described in a previous article, and with a carriage which runs the gun forward to the loading position automatically to secure rapid repetition

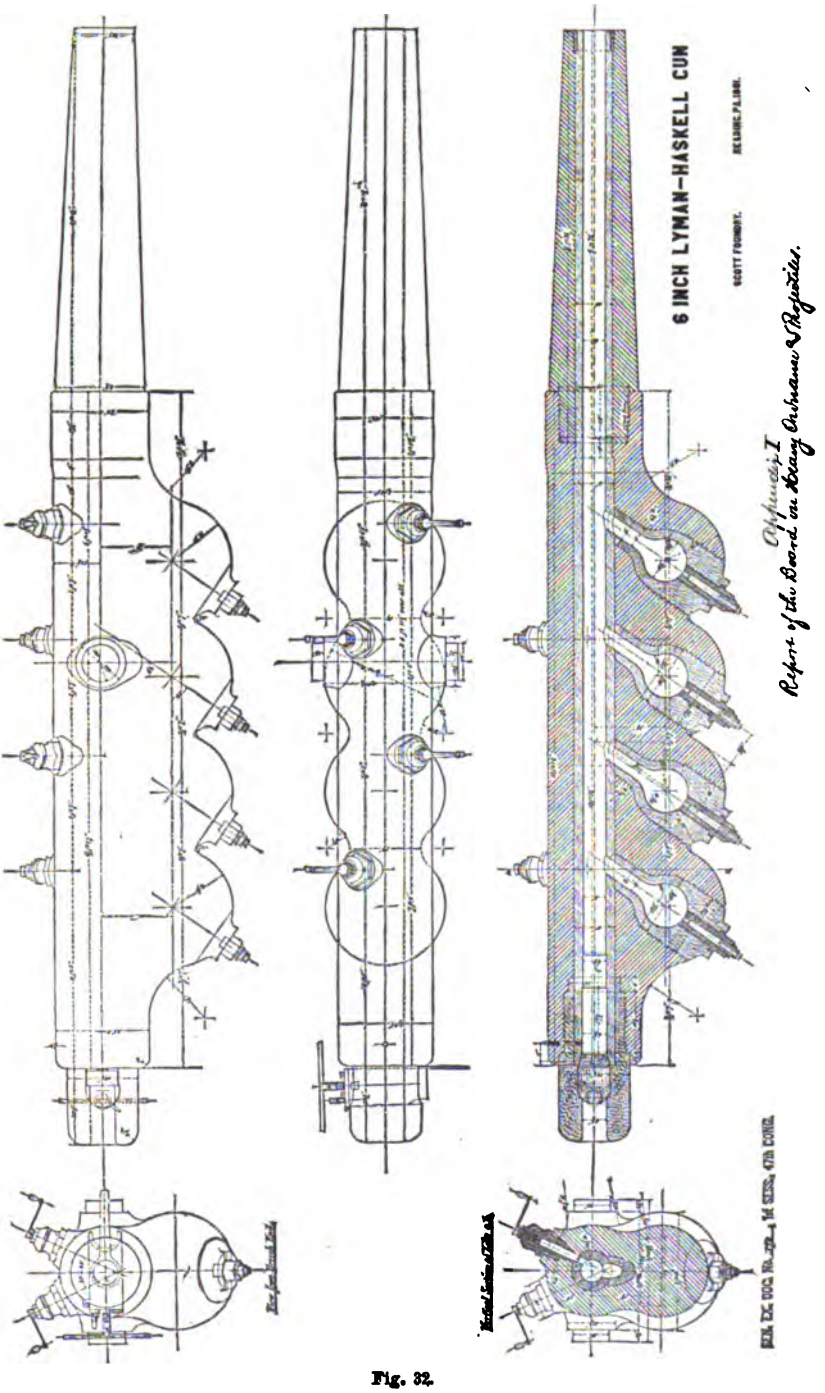


Fig. 32.

of fire possible with the use of mechanically fitting centered anti-friction projectiles; thus making a far more powerful and enduring gun than the Lyman-Haskell theoretical one, which will cost forty times as much, and, on account of its slower rate of repetition, only perform one-fortieth part as much work. That is, I propose to convert one gun from a 15-inch smooth-bore, which will fire twenty times as rapidly and give twice the power to each shot, for one-fortieth part of the cost of one gun made on the following plan:

1017. The friction of one compressed projectile passing out of this gun, impelled by five impulses of quick-burning charges of powder, will heat the lining tube 3,000 times as much at least as my projectile by its reduced friction would heat the surface of the bore of my gun; and what is previously written in this paper on the effects of unequal expansion, arising from the friction of tightly fitting projectiles, sufficiently indicates what will happen to this gun of only 6-inch caliber when it comes to be proved: And no loosely-fitting projectile can be used with this system.

1018. It was a happy thought of the promoters of this enterprise to secure an appropriation for a larger gun of this kind before the one already made, of smaller caliber, could be tested.

1019. In my letter dated 27th July, 1880, addressed to the Secretary of War, before quoted from, I said:

1020. "By the reduced rate of combustion and the reduction of strain upon the gun, we may use increased charges, provided the capacity of the bore is sufficient for the

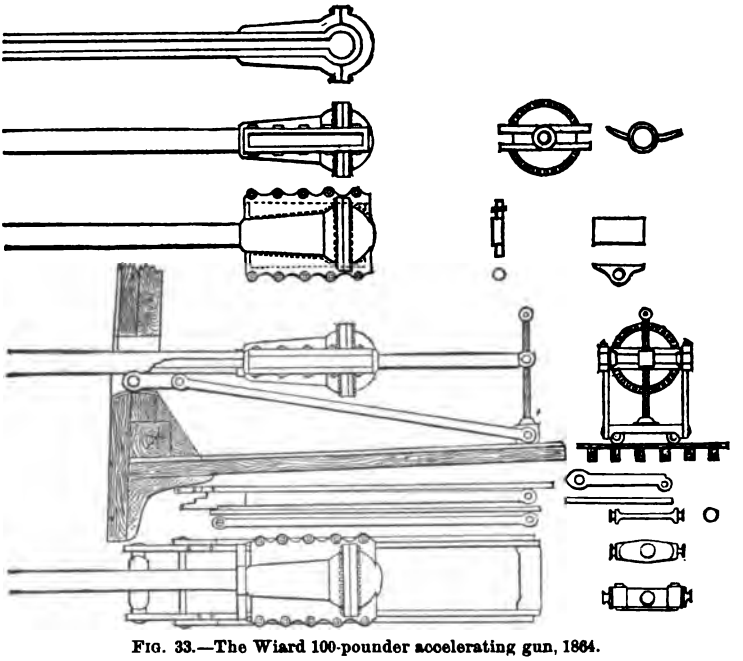


FIG. 33.—The Wiard 100-pounder accelerating gun, 1864.

utilization of expansive force of the gases of the powder, and the length of bore is sufficient to give time for the combustion, so that no part of the charge shall escape unconsumed. But it can be seen that as projectiles for rifled guns are at least two calibers in length, as powder is but about one-eighth as heavy as iron, if we increase the charges to one-third the weight of the projectiles, we shall occupy at least three calibers of length of the bore with the powder charge, or about one-fourth of the bore of ordinary guns.

1021. "By increasing the diameter of the powder chamber one-third, as I propose to do in my improved breech-loading twelve-inch rifled gun, which retains for the length of the chamber the caliber of the fifteen-inch gun from which it is converted, we reduce the length of the cartridge one-half, or nearly, and thus secure longer time of actions on the projectile, as well as a better quality of combustion, without increase of the length of the gun, if it is desired to keep the gun within its normal dimensions. But with powder chamber of enlarged dimensions, to which the rifled portion of the bore is sub-calibered, and a sub-caliber projectile, increased length of bore, in combination with slow-burning powder, all possible advantage to the gun proper may be seemingly secured.

1022. "These, together with centering the projectile in the bore, with windage all around the sabot alike; the non-expansible and anti-friction character of the projectile, together with the combination of smooth-bore and rifle in one gun, seem to leave nothing to be desired.

1023. "The carriage, and manner of mounting the gun upon it, add to the efficiency, precision, and endurance of the gun. Its rapidity of repetition of fire and reduction in the number of men required to work it are also important improvements.

1024. "It is said that Krupp has already secured remarkable increase of velocity and power by the increase in the length of the bore of a trial gun, and has utilized a charge of powder equal to the weight of the projectile in the guns referred to; and we find reference to chambered and long-bored guns in the report of the Chief of Ordnance for 1879.

1025. "The writer is not, however, much indebted to these sources of information, as in a letter dated March 30, 1864, addressed to the Chief of the Bureau of Ordnance of the Navy, he forwarded drawings and specifications for a long-chambered, breech-loading gun of 6-inch caliber then in course of construction—being the second of the class—at his works at Trenton. (See Fig. 33.) The bore was forty calibers of length, and the chamber of spherical form was of capacity to contain 80 pounds of powder, while the projectiles were to be of 100 pounds weight. The gun, as the drawings showed, was to be mounted on a wrought-iron carriage, and its recoil would be in the direction of the axis of the bore at all elevations. A copy of the letter to the Chief of Ordnance will be found on page 85, Ex. Doc. No. 11, Forty-first Congress, first session.

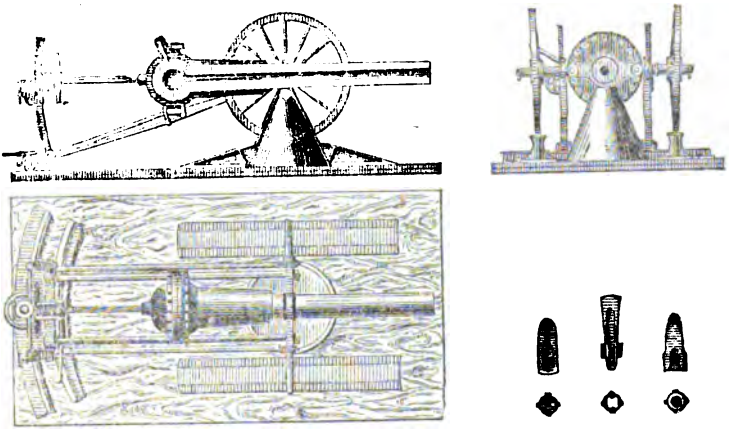


FIG. 34.—The Wiard 20-pounder accelerating siege gun, 1864.

1026. "At the time this gun was invented and made, the knowledge of how to best constitute grains of powder to secure reduced strain upon the gun, together with higher velocity to the projectile was not common. The writer, however, had caused a smaller gun (Fig. 34) of the same kind to be constructed with a view to experiment, but he was deprived of the chance to conduct the experiments devised, as an agent, in his zeal to show a gun to a party of distinguished gentlemen from New York on a visit to his works, fired it four times with full charges of such powder as was on hand, during the absence of the inventor. At the fourth round the gun cracked in the chamber. The projectiles, were fired into a bank covered with original sod of grass of many years' duration. After much labor in endeavoring to recover them, without success in finding them, the search was abandoned. One year afterwards, my attention having been accidentally called to the fact that the projectiles had not been

found, I caused the search to be renewed, and they were found, having made the remarkable penetration of *forty-six feet* through hard-packed sandy loam.

1027. "This result, with a gun of 4-inch caliber, a spherical chamber of ten inches, a powder charge of ten pounds (No. 7 Navy), and a projectile of 20 pounds weight, afforded me the suggestion upon which I proceeded towards the design of the improved breech-loading 12-inch rifled guns to which my proposal relates. It has not been the result of sudden inspiration, but has been developed with all its parts and attachments through more than sixteen years of observation, overlooking practical experiments, and laborious study of the effects and the uses of gunpowder."

1028. It can be seen that both these guns are so mounted as to direct the recoil in the line of the long axis of the bore at all elevations. This feature is also prominent in the automatic carriage for my long bored and chambered gun, included in my proposal now before the committee.

1029. In connection with a proposal for ordnance experiments, 28th March, 1881, I wrote a letter to the Secretary of War, of which the following are extracts, cited to show that coiled welded linings for guns were inadmissible; that that mode of lining guns had been tested over and over again during the past 150 years and had failed as often as tried:

"312 SIXTH STREET, N. W.,
"*Washington, D. C., 20th May*, 1881.

"The Hon. ROBT. T. LINCOLN,
"*Secretary of War:*

1030. "SIR: In compliance with your request, I hereby present such reasons as occur to me why you ought not, perhaps cannot, hereafter legally permit further orders or contracts to be made or awarded for the construction or conversion of heavy guns, projectiles, or ordnance supplies according to plans secured in advance by patents issued to officers or agents of the government, of the Army, or the Ordnance Corps, especially for *guns* of cast iron lined with a *coiled welded wrought-iron tube* to be used with expanding projectiles."

1031. The following were quoted from well-known authorities:

1032. "(C 1.) Holley, page 344: 'The grand defect of wrought iron is that it is not homogeneous. The puddling process by which it is produced, the piling process by which large masses are aggregated, and the welding process, by which all parts, large and small, are united, are all the means of interposing strata of impurities and lines of weakness.'

1033. "Mr. Kirkaldy, 'Experiments on iron and steel,' 1862, says: 'A great variation exists in the strength of iron bars which have been welded; *whilst some bear almost as much as the uncut bar*, the strength of others is reduced fully a third.'

1034. "Mr. Anderson, *Superintendent Royal Gun Factories*, in a paper read before the 'Royal United Service Institution,' February 14, 1862, said: 'In the construction of the Armstrong gun the bar-iron is *first wound into a spiral coil*, and then a *welding heat is taken* through the entire mass, *and by means of a steam hammer it is welded into a homogeneous cylinder*. With iron of the very best quality which we have as yet been able to obtain, the highest *average* tenacity of the *welding* of the coil has been 32,140 pounds per square inch; the iron being 55,500 pounds.'

1035. "*With other iron*, also of high quality *and* still *greater tenacity, the welds have been lower down*, even to 10,000 pounds per inch."

1036. "Major W. Pallisser, replying to remarks made by Captain Mulloney, assistant to Colonel Campbell, superintendent of the gun factories, upon the paper read by Captain Pallisser before the 'Royal United Service Institution,' June 15, 1858, said: '*The strength of a chain is measured by its weakest point.*' Captain Mulloney had previously said: 'The lecturer has taken credit for a great many things being discovered by the trials of his three heavy guns. He has told you the history all three of them, *and they were all failures.* [Italic in the text.] The first of them failed by bursting of the interior tube. At the 182d round it became unserviceable. No one in his senses would think of going on with a gun when he saw a great crack on the surface extending some way down. Major Pallisser states that there was a defective weld in the chamber of that gun which showed by the gun not bursting that there was no want of longitudinal strength in it; that the cast iron bore all the longitudinal strain. But *that* defective weld never went through the barrel. * * * I do not know what the thickness of the barrel is, but the wrought iron bore the whole of it. * * * It has been stated that the casting of that metal around the wrought-iron tube deteriorated it. * * * Now, of that very gun which burst, a few days ago at Woolwich we took a piece for testing, and found *it was not deteriorated.*'

1037. "Major PALLISSER: 'That gun was my property; what right had you to do that? I said our specimen cut out of the 12-inch gun broke at a strain of 13 tons per square inch, and if one part of the barrel broke it was quite sufficient."

1038. "Mr. ROBERT MALLET, C. E., F. R. S., a well-known civil engineer, in criticising Major Pallisser's paper above referred to, said: 'I say Major Pallisser's construction is altogether based upon a fallacy.' 'You see the fallacy brought to its *reductio ad absurdum* in that gun [pointing to the diagram of the burst Pallisser gun], which seems to me to be a condemnation of the whole system of cast iron put over wrought iron.' 'I may remark that all this business that makes so much noise seems to me to lack novelty altogether.' 'It is at least one hundred and fifty years old.' 'The celebrated Remaur suggested—(M. Villons and other makers having failed to make wrought-iron guns on much the same system which Treadwell, Prof. Daniel Treadwell, of Cambridge, Mass., in America, has brought up again)—Remaur suggested the idea of making a wrought-iron tube, making it by a coil, and putting it inside a cast-iron gun.'

1039. "The Marquis de Courtiron and M. de Boucher, French ironmasters, between 1755 and 1780, both reproduced the same idea.' 'Monge, the celebrated author of the "Geometric Descriptif," reproduced the same idea in 1813, after the disasters of the Russian campaign, when the French artillery was gone and the question was how it was to be restored in a few months.' 'There is nothing new in the idea of putting a wrought-iron tube in a cast-iron gun.' 'I fail to see the merit of it in point of novelty, and I fail to see the merit of it in a practical point of view. * * * The mere fact that they have recommended guns to be converted this way fails to convince me that it will not be a positive national disaster if any considerable number of our guns be converted on any such system.' 'In support of that I can do no more here than venture a bold assertion. I say upon that system you will never have a safe gun.' 'I say further, that you will never make any gun that exists in the British service when so converted a useful gun. * * * Attempt to convert them upon this plan, and you will simply destroy them as smooth bores, and you will make them perfectly useless for any purpose, * * * utterly untrustworthy as rifles.'

1040. "The CHAIRMAN. 'Do you wish to reply, Major Pallisser?'

1041. "Major PALLISSER. 'I must say before replying that I think it scarcely fair to a man not much given to public speaking to have to jump up and reply at a score to a carefully prepared attack by a well-known man like Mr. Mallet. I rather deprecate it that in the discussions in this place one is rather put up as a target for every one to have a shot at.'

1042. "Mr. MALLET. 'Allow me to answer you that until I came into this room I had not the slightest idea of saying one word. It was not until after 4 o'clock to-day that I knew you were going to deliver this lecture, and not one word that I have said was prepared.'

1043. "Captain R. A. E. Scott, R. N., in some criticisms upon a paper read before the Royal United Service Institution, March 18, 1867, by Major Pallisser, said, in referring to welds of coiled tubes: 'There is another point I would mention. As far as we have experience at the present time of coiled tubes it is exceedingly difficult to weld them together so as to make a complete joint. When fired with high charges the coils separate.' 'When that gun of Sir William Armstrong—the 300-pounder, which afterwards blew its breech out—was proved the coil changed in the proof. At each round there was an alteration in the inner tube.' 'We know that there is great difficulty in welding an iron tube so as to make it stand for the interior of a gun, and you cannot put cast iron on the outside of a steel tube. The only gun that was tried that was made in that way burst at the first round.'

1044. "April 23, 1863, Mr. Whitworth said to the Select Committee on Ordnance: 'I believe the very worst material that can be used for a gun is welded metal.' 'I have never yet made a gun with a tube of welded iron. I would never think of doing so.' 'I disapprove of Mr. Clay's system also, and of all systems that include the use of welding wrought iron.'

1045. "J. Anderson, Superintendent Royal Gun Factory, said to Select Committee on Ordnance:

1046. "'Question 1981. Have or have not most the defects in the guns occurred in the weld of them? Yes, the greater number.'

1047. "Sir William Armstrong said: 'I admit that welds are very objectionable in the barrel in all cases.'

1048. "Captain Blakely said: 'I may say that I consider that the coil system was at that time a mere makeshift. The object of the coil system is to get welds of wrought iron around the gun in that form in which they will be least mischievous.'

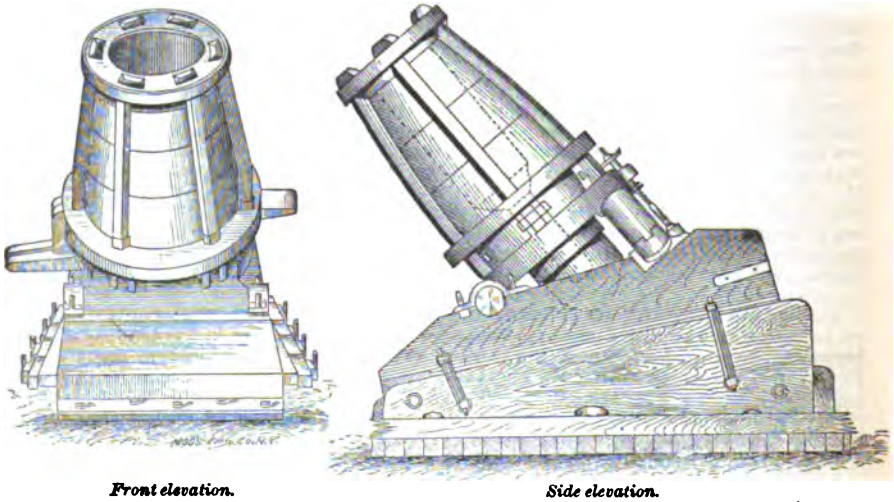
1049. And I said:

1050. "The facts publicly known in 1868 were that the capture of Mason and Slidell by one of our naval officers suggested serious complications, and the colonies, notably Canada and Australia, apprehending difficulties, began agitation in their colonial

legislatures with a view to procuring cannon for coast defense on their own account, and the committee having charge of armament was directed by the Secretary of State for War to make some concessions to pacify them. The report said: 'The committee do not hesitate, *with these facts before them*, to recommend an extensive conversion of our present cast-iron smooth-bore guns into rifle guns with linings of coiled iron *for secondary purposes of defense*. Experiments recently made *show the possibility of controlling the recoil of the gun* of only 5 tons weight when firing the full battering charge of the 7-inch guns of 6½ and 7 tons upon an ordinary 68-pounder wooden platform at 5° slope strengthened and fitted with the American compressor; and although the committee *are not prepared to recommend such large charges for lined 68-pounders*, they consider these experiments to have proved *that such guns may*, SO FAR AS THE SHOCK ON THE CARRIAGE AND PLATFORM IS CONCERNED, be used on traversing platforms with charges beyond those appropriated to shell guns, *and therefore be included in the lists of guns for conversion with a view to their employment for harbor defense in India or by any of the colonies that may desire so to utilize guns that are already colonial property. The committee do not recommend them for coast and harbor defense at home, believing* that if this country is ever called upon to defend its shores it will be against the most powerful ships and heaviest guns that can be produced, and that its coast defenses should be of corresponding efficiency. For the same reason they should perhaps not enter into the armament of maritime fortresses of the first class, such as Gibraltar, Malta, Halifax, or Bermuda.'

1051. "It is fair to presume that if the English committee had apprehended a war with the United States they would have been highly pleased to know that our ordnance authorities had adopted the plan of converting our cast-iron guns into rifles by lining them with a 'coiled welded wrought-iron tube.'"

1052. The following represents the "monster mortar" of Mr. Robert Mallet, C. E., F. R. S., made for the English Government many years ago. Its caliber was 36 inches—the largest bore ever made and tested as a piece of ordnance. Its shells, huge spheres of 3,000 pounds, contained tremendous bursting charges of powder. In falling within the lines of the defense the penetration was considerable, and upon bursting formed a crater of great extent, and scattered destruction to surrounding structures:



Front elevation. *Side elevation.*

FIG. 35.—The monster "Mallet" mortar.

1053. This great bombard was intended for seige operations, and for convenience of transportation was built up in sections each of manageable weight, which could be taken apart and assembled again with facility.

1054. It was composed of a powder-chamber piece with a broad flange, three cylindrical rings, and a muzzle-piece with a flange.

1055. These parts were recessed one into the other to secure true concentric relations to each other, and the whole was held together by six strong lengthwise bars or bolts, intended to prevent by their lengthwise compressive force the separation of the parts; in other words, to give the required transverse strength. It seems that no other force than that resulting from the friction of the projectile as it was being ejected from the bore was apprehended, inasmuch as the recoil would be mostly restrained by the solid foundation of the bed upon which the whole structure rested.

1056. There was, however, an unapprehended force acting to separate these strong outside bolts.

1057. The interior of the bore exposed to the heat of the gases of powder and to the heat-engendering friction on its surface, proved to have the effect of creating forcible lengthwise expansion sufficient to break these bolts, separating them one after another, but not explosively, and after resupplying one after another, stronger and stronger than the preceding ones, the whole of the magnificent and costly structure had to be abandoned, and the great mortar was relegated to the "cemetery of suicides," where if it does not *requiescat in pace* it does *rest* in *pieces*, surrounded by hundreds of costly burst guns, most of them monuments to the imbecility of invention and paucity of knowledge in relation to the physical properties of metals, the laws of force, and the effects of unequal heating.

1058. Mr. Mallet, however, like a true philosopher, did not permit his labor and expenditure to be lost. He wrought out a common sense and useful explanation of the phenomena as affected by unequal heating and cooling of metals while being fabricated into larger than usual masses, as well as when used in such structures as guns, causing the destruction or, at least, the disabling of those in particular made of the strongest materials. His essays on these subjects have been freely quoted by me in the papers I have laid before the committee, and I hope they will receive due consideration.

1059. In February, 1865, upon invitation, I addressed a "communication" to the committee on the "conduct of the war," which was ordered to be printed (S. Mis. Doc. No. 47, Thirty-eighth Congress, second session). The subject of this communication, which was illustrated by cuts, was the bursting of guns; on page 18 will be found the following (Fig. 36), representing—

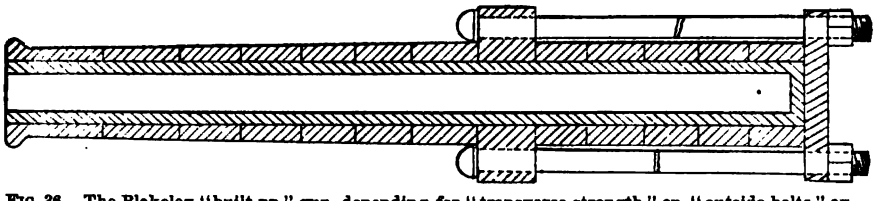


FIG. 36.—The Blakeley "built up" gun, depending for "transverse strength" on "outside bolts" extending from the "trunnion ring" to a breech supporting "cascable part."

1060. This cut was associated in my argument; with a cut (*ante*, Fig. 18) representing a Whitworth gun with a protruding tube; a cut (*ante*, Fig. 19) representing an Armstrong 300-pounder with the breech pushed out by the lengthwise expansion of the lining tube; a representation of a Parrott gun, with its breech pushed out by the lengthwise expansion of the inner metal of its cast-iron "banded" tube, and cuts showing views of

an Armstrong field-gun with one of its outside bands at length, split longitudinally by the tangential expansion of the lining tube.

1061. In all these examples I showed that the ruptures had resulted as the direct effect of unequal expansion from unequal heating.

1062. Captain Blakeley said in a paper read before the Royal United Service Institution, January 21, 1859, referring to the gun—Fig. 36—which had been disabled more than once:

1063. "At this round [the fourth] the four bolts gave way, the four united being equal to a solid bar the size of the bore. *The rest of the gun was uninjured.*"

1064. An examination of the cut, Fig. 36, shows that the bottom of the tube was closed, the closure forming part of the tube, which "was uninjured." It is, therefore, evident that it was not the direct elastic pressure of the gases of gunpowder acting against the bottom of the chamber which broke the bolts. If we should fire a shot at a target composed of *two* iron plates we could not penetrate the rear plate without first penetrating the front plate, neither could the outside bolts be broken by the expansive force of the powder without first perforating through the closed breech of the tube and *projecting* the broken end of the tube backwards with the other *debris*.

1065. But the tube and the bands shrunk upon it of such aggregate thickness or thinness (in fact, the total thickness was, in this gun, within the ordinary thickness of the walls of a field gun, which heats throughout and therefore does not burst from the effects of unequal expansion) as to be heated through bands and all, the widthwise expansion of the bands and the lengthwise expansion of the tube did, therefore, furnish sufficient force to break the bolts, "without injury to the tubular parts."

1066. Captain Blakeley further says—

1067. "I had this gun remade, with bolts of the best charcoal iron; but they, too, broke, without injury to the tubular part."

1068. The authorities I have quoted throughout all the papers I have presented to the committee are standard authorities, accessible to all students and professors engaged in invention, designing, manufacture, or the utilization of armament, armor, or ordnance. The theories I have advocated, the experiments concluded, the successes and failures reached. To an earnest student and experimenter failure in the demonstration of a theory may prove a real success if followed up intelligently, holding fast to that which is good and leaving the bad behind, especially all that relates to the failure of lining tubes for the conversion of cast-iron guns, or new constructions using lining tubes, either of welded wrought iron or of steel, and by expanding, wedging, jamming, and balloting projectiles cannot but be well known to General Benét, Colonel Crispin, General Getty, and every member of the boards of 1872 and 1882.

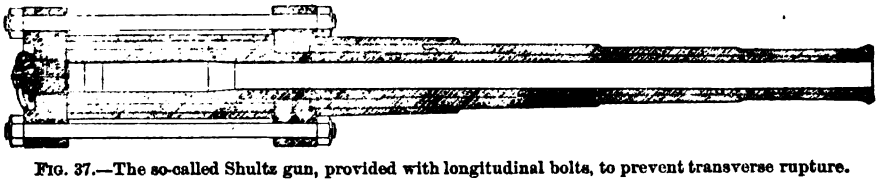


FIG. 37.—The so-called Shultz gun, provided with longitudinal bolts, to prevent transverse rupture.

1069. The failure of Captain Blakeley's gun, Fig. 36, has been described minutely in the reports of the United Service Institution, and in various public documents to be found in document rooms, Congressional and other public libraries, and in several of the War, Navy, and other of the

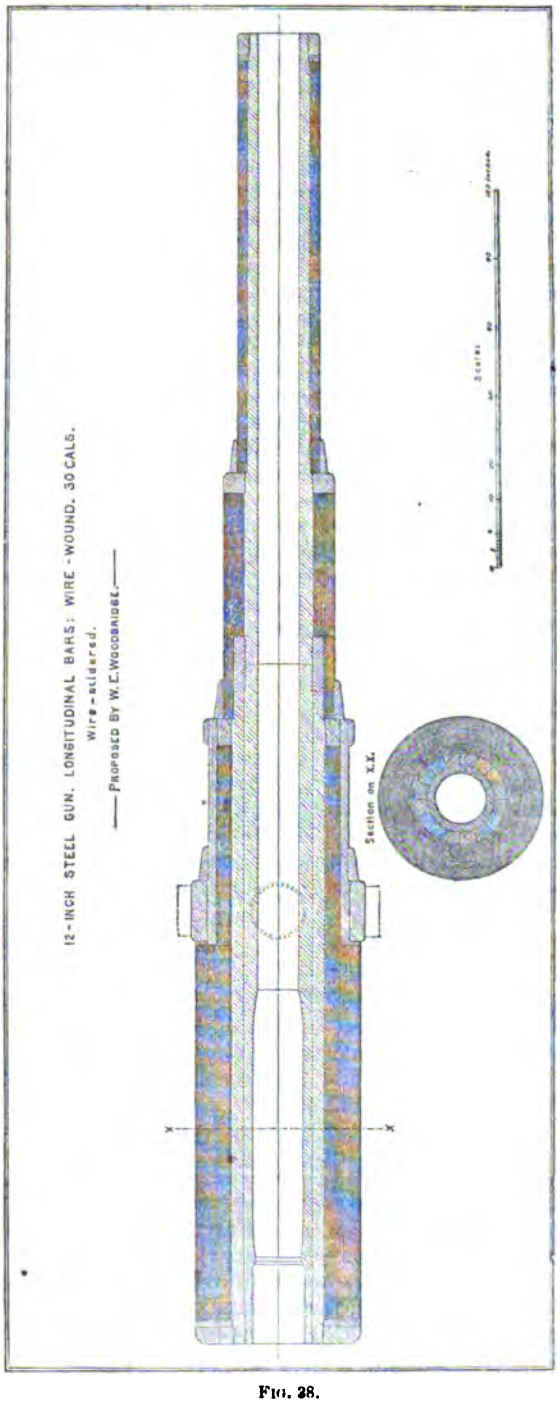

12-INCH STEEL GUN. LONGITUDINAL BARS: WIRE-WOUND. 30 CALS.
Wire-soldered.
Proposed By W.E. Woodbridge.
Section on X.X.

FIG. 28.

departmental libraries; yet among the projects for heavy breech-loading rifled guns, presented to the Getty Board, and recommended to Congress for appropriation and manufacture by that Board I find the so-called "Shultz," Fig. 37, urged before the Board by Colonel Crispin, the late official inventor (?) of the Ordnance Corps, late President of the Ordnance Board, late Constructor of Ordnance (late, seemingly, and far behind the times in everything).

1070. This gun, it will be seen, is identical in its general construction with the Blakeley gun (Fig. 36) except that the lining tube is open at its rear end, the only effect of which is that the whole of the expansive force exerted by the charge, in addition to the force of the unequal longitudinal expansion of the tube and bands between the trunnion ring and the cascabel part, is to be restrained by the outside bolts, which cannot be heated either by contact with the hot gases or by conserved heat arising from the friction of the wedging or jamming projectile. General Benét has said that "Colonel Crispin is considered a very ingenious man." He certainly seems to exhibit most extraordinary ingenuity and persistent effort in finding out and speciously presenting the most useless and obsolete, even ridiculous, projects for abstracting and obtaining money from the Treasury, and retarding progress towards improvement in ordnance.

1071. If the Blakeley plan of resisting transverse rupture by the strength of longitudinal bolts was a failure, how can it be expected that longitudinal bars, as in the Woodbridge gun (Fig. 38), will succeed any better.

1072. I have a faint recollection that something like the following has been said, and I agree, that "iron bolts [nor bars] do not a prison make, nor lining tubes a cell" in which the force created by the combustion of a powder charge in a gun can be confined, if expanding projectiles are used.

1073. In this gun (Fig. 38) it can be seen that the wire-wound part does not add to the transverse strength. I predict that this gun, if it is ever made and tested, will, in its bursting, partake more of the nature of an explosive burst than the first gun (Fig. 39) produced by the same expert, which opened a transverse fracture gradually, beginning on the outside in a fine crack and extending and opening as the lining tube expanded, till the whole gave way.

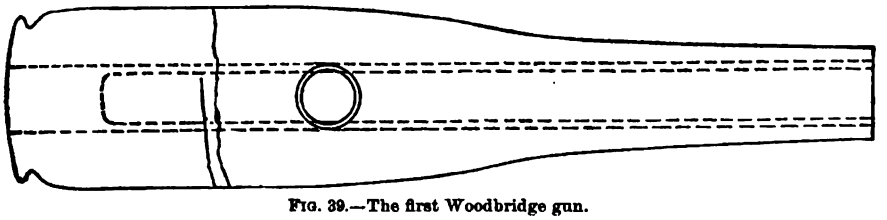


FIG. 39.—The first Woodbridge gun.

(See photographs which accompany the report of the Getty Board.)

Senators, there has no day passed since the 25th of May, 1861, during which I have not devoted a few hours to study or experiment looking to the solution of the ordnance problem.

1074. I believe I am at least as familiar with the history of all ordnance constructions and all public ordnance experiments, wherever conducted, as any one in the world.

1075. In all the years I have devoted to the subject I have only known of one kind of successful gun besides my own Nut Island guns of 8-inch caliber or larger which has endured the test of battle and long service,

and that one kind was made of cast iron, and has only been successful in so far as it has been used with centered projectiles. I allude to cast-iron smooth-bore shell guns used with a wooden sabot and straps, of which I know of two examples, the Dahlgren IX-inch and XI-inch shell guns and the English 68-pounder (Fig. 40). Captain Alden testified to the committee on the conduct of the war:

"WASHINGTON, *January* 23, 1865.

1076. "Captain JAMES ALDEN sworn and examined.

"By the Chairman:

1077. "Question. What number and caliber of guns had you on board the Brooklyn in your expedition against Fort Fisher?

1078. "Answer. We had twenty 9-inch guns, two 100-pounder Parrotts, and two 60-pounder Parrotts—all four of the Parrotts rifled.

1079. "Question. How many times were those guns fired in the two attacks upon the fort?

1080. "Answer. I threw into that fort 3,400 9-inch shells—over 120 tons.

1081. "Question. How did the guns bear that shelling?

1082. "Answer. As soon as I heard of the 100-pounders bursting, I put mine on the opposite side of the ship from that with which I was fighting, and put in their places the 9-inch guns, so that I had twelve 9-inch guns in battery all the time.

1083. "Question. Then you did not use those 100-pounder Parrotts?

1084. "Answer. Not after I heard of the accidents with them on the other ships. I never fired them again.

1085. "Question. Were those 9-inch guns made on the Rodman principle?

1086. "Answer. They were Dahlgren guns.

1087. "Question. *Were they cast hollow, or otherwise?*

1088. "Answer. *They were the Dahlgren 9-inch guns, the best gun ever made.*

1089. "Question. What effect had that firing upon them?

1090. "Answer. I never discovered that any of them were injured.

1100. "Question. Did none of them fail?

1101. "Answer. Not in the slightest degree. The men stand around them and fight with them with as much confidence as they drink their grog."

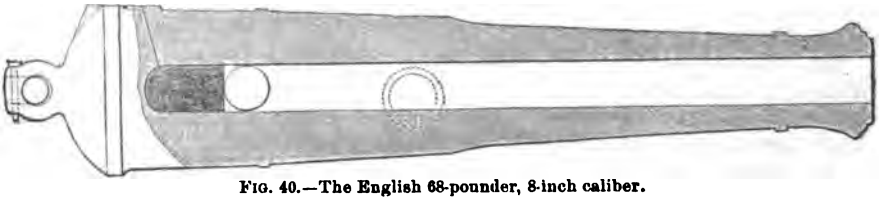


FIG. 40.—The English 68-pounder, 8-inch caliber.

1102. Although the English Government have expended about $50,000,000 for cannon, I doubt if they have a single reliable gun in service except of this one kind.

1103. There is not, never was, nor ever will be a successful rifle gun of 8-inch caliber or larger, used with expanding, uncentered, wedging, jamming, wabbling or balloting projectiles for battle service, *i. e.*, rapid firing for thirty or forty consecutive rounds, without bursting.

1104. With centered mechanically fitting projectiles, long bearing in the grooves and improved powder, chambered and long-bored guns, mounted on automatic carriages to facilitate rapid firing, powerful, enduring, and cheap armament can be produced by conversion of cast-iron guns on hand, or new constructions can be procured more cheaply than of any other material. This was triumphantly proved by the results of the Nut Island experiments.

1105. It, however, requires further experiment to perfect the details and adapt parts of the system to other parts, to secure a symmetrical whole. My proposal provides for this, and if it is accepted, I doubt not the ordnance problem will be solved, leaving nothing to be desired for the present or near future.

Respectfully,

NORMAN WIARD.

1.

REMARKS OF CHIEF OF ORDNANCE ON PROPOSITIONS AND DESIGNS SUBMITTED TO THE COMMITTEE BY INVENTORS AND OTHERS.

NORMAN WIARD.

The plan of converting smooth-bore guns into rifles, as proposed by Mr. Wiard, presents three fatal objections, viz:

1st. The employment of a comparatively weak cast-iron gun, intended for service as a smooth bore only, for the much heavier strains imposed by the use of rifle projectiles, and that, not only without any corresponding addition to the strength of the gun, but with an actual reduction of its original strength, caused by cutting along the bore three deep grooves for the rifling. Under the most favorable condition the employment of cast iron alone for rifled guns is objectionable and has been every way discarded.

2d. The employment of flanged projectiles that have been abandoned in all services as very dangerous, from their liability to override the lands, break and jam in the bore, and produce rupture of the gun. Such projectiles are further objectionable from allowing a large escape of gas around the body of the shot, which soon produces serious erosions and gutterings of the bore of the gun, besides occasioning a considerable loss of power.

3d. The employment of a form of projectile that is of very questionable value as regards accuracy of flight and ability to sustain its velocity, while its destruction effects against armor plates are greatly reduced by its losing about one-third of its weight upon import.

As regards the Nut Island experiments referred to by Mr. Wiard, the following statement, compiled from the official reports of the Nut Island experiments, and published in Part 9, House Mis. Doc. 170, Forty-fourth Congress, first session, is most instructive, as showing the endurance of the Wiard guns:

RECORD OF ENDURANCE OF WIARD GUNS TESTED AT NUT ISLAND.

Date.	Nature of gun.	No. of guns.	Charge.			Projectile.			Total number of rounds.	Remarks.
			Kind of powder.	Weight.		Kinds.	Weight.			
				Maximum.	Minimum.		Maximum.	Minimum.		
				Lbs.	*Lbs.*		*Lbs.*	*Lbs.*		
1873–'74	XV-inch Wiard smooth-bore, new gun.	1	Oriental mammoth....	140	50	Spherical	450	.....	16	
1873–'74	XV-inch Wiard rifle, new gun.....	1	....do	140	50	Wiard conical.....	453	.....	19	Burst at nineteenth fire from the use of excessive charges and the breaking in the bore of a Wiard projectile.
1874	XV-inch Wiard Navy rifle, converted from a Navy 15-inch S. B.	78	....do	180	50	Wiard conical and subcaliber.	492	.....	2	Burst at second fire from the use of excessive charges and the breaking in the bore of a Wiard projectile.
1875	XV-inch Wiard rifle, converted from 15-inch Wiard S. B. No. 1.	2	Oriental hexagonal....	100	{55 / 70}	Spherical and Wiard mitten.	529½	450	7	
1874	XI-inch Wiard rifle, new gun.....	1	Oriental mammoth, Oriental rifle, and Bickford rifle.	100	50	Wiard conical copper veneered.	260	.....	3	Burst at third fire from the use of excessive charges and the breaking in the bore of a Wiard projectile.
1875	XI-inch Wiard Parrott rifle, converted from Army 300-pounder (10 inch) Parrott.	10	Oriental hexagonal....	60	40	Spherical and Wiard mitten.	308	168	20	Burst at twentieth fire (and at third fire with round shot) from having been previously overstrained from the use of excessive charges and Wiard projectiles.
1874	IX-inch Wiard-Parrott rifle, converted from Navy 150-pounder (8-inch) Parrott.	85	Oriental mammoth....	20	10	Spherical and Wiard conical.	190	90	38	"Laid aside" after thirty-eighth fire.
1875	IX-inch Wiard-Parrott rifle, converted from Army 150-pounder (8-inch) Parrott.	34	Oriental hexagonal....	40	.....	Wiard mitten.....	171	.....	1	First fire cored "mitten" shot broke up in the bore, completely ruining gun.
1875	IX-inch Wiard-Parrott rifle, converted from Navy 150-pounder (8-inch) Parrott.	33	....do	40	30	Wiard mitten.....	204	.....	2	
1874	VII-inch Wiard-Parrott rifle, converted from Navy 100-pounder (6.4-inch) Parrott.	161	Bickford rifle	15	10	Wiard conical	100	.....	13	'Laid aside" after thirteenth fire.
1875	VII-inch Wiard-Parrott rifle, converted from Navy 100-pounder (6.4-inch) Parrott.	55	Oriental hexagonal....	20	.....	Wiard mitten.....	87½	.....	3	First fire solid "mitten," shot broke up in the gun, damaging grooves.

PARROTT RIFLES EMPLOYED IN COMPARATIVE FIRINGS WITH WIARD RIFLES.

150-pounder (8-inch) Navy Parrott rifles.	84	Oriental mammoth....	20	10	Spherical and Parrott..	149½	63	42	Laid aside.
100-pounder (6.4-inch) Navy Parrott rifles.	263	Bickford rifle	15	10	Parrott	75	.....	9	

SUMMARY.

Aggregate number of rounds fired from Wiard guns	124
Greatest number of rounds fired from any single Wiard gun	38
Total number of Wiard projectiles that broke in the bore of guns	7

An examination of this table shows that of the twelve guns furnished, *ten* were Wiard guns and used the Wiard projectile. Of that number the column of remarks shows that the total number of guns in any way injured was *six*, or 60 per cent. of the lot, and that the number burst or totally ruined was five guns, or 50 per cent. of the lot. The latter casualties all occurred during an aggregate of 45 rounds, or at the rate of one gun for every *nine* rounds. It will also be observed that the largest number of rounds fired from any one of the Wiard rifles is only 38 rounds, or less than one-tenth of the number required for the test for endurance of heavy experimental guns. From this we can understand how far short the Wiard guns have fallen of a suitable degree of endurance. As to causes of the above disasters, the testimony of Commander Brown, U. S. N., is uniformly clear and explicit, and to the effect that they are to be found in the overstraining of the gun in the use of excessive powder-charges, and the employment of a bad system of projectiles.

Regarding the *power* of the Wiard guns, as shown by the penetration of iron plates in the Nut Island experiments, also regarding their *accuracy of fire*, it may be shown, from the Mis. Doc. above cited from, that a comparison in these respects, so far as it can fairly be made with the Navy Parrott rifles we find in the Nut Island experiments, is favorable to the superiority of the Parrott gun.

As regards *absolute* power of penetration into heavy armor plating, however, the results obtained in the Nut Island experiments are of little value. The iron plates used for the targets were made up of a large number of plates of little thickness. Targets thus made afford much less resistance to penetration then where, for an equal total thickness, only one or two plates, but of greater individual thickness, are used, the maximum resistance being attained with a single plate.

These plates, moreover, were not even bolted together, which is the ordinary condition under which armor plating must be encountered, and adds not a little to its resistance. They were merely set up in frames, in which it was not possible to obtain the support that is to be derived from bolts. Further, the quality of the metal in the plates was very bad, as appears from the effects produced by the projectiles in striking them, viz: The plates were broken up and scattered about, and those at the back of the target, not penetrated by the shot, were badly cracked, all behaving like so much lost iron.

As regards the quality of the metal in these plates, Mr. Wiard himself, in his letter, page 167, Mis. Doc., to the Secretary of the Navy, in applying for them, as part of a lot of old material on hand at the Charleston navy-yard, states that they were "unserviceable and unsalable."

To understand this question—the qualities of good wrought-iron armor plating—I will refer to experiments made in Europe.

General Barnard, in his "Supplementary report on the fabrications of iron for defensive purposes," quotes, for "engineering," on the firings against 12, 8, and 6-inch solid plates, in 1861, as follows in regard to the quality of the plates:

> The character of the metal in the plate may be judged of by the fact that the shot holes were as clean as they possibly could be, no crack or fissures appearing, whilst the holes were the veriest trifle larger than the projectile which had made them.

In another place he quotes from the professional papers of the Royal Engineers, in reference to the mode of proving armor plates, as follows:

> The proof is carried out by firing a Palliser shot from the 7-inch M. L. rifle gun at 30 yards, with a 9-pound charge. A good 5-inch plate will stop this shot; and if very

good it will show only a slight star crack, and bulge in rear. An indifferent plate will let the shot through, and have a large piece taken off the back. A bad plate will let the shot pass easily through, and perhaps crack a good deal, or even break in pieces.

In the reports of the firings of the 12-inch rifles, with 85-pound charges and 600-pound shot, against a 14-inch solid plate target at 200 yards distance, at Shoeburyness in 1871, the account is given:

Round I.—Diameter of shot-hole, 13 by 12.7 inches; penetration, 13.99 inches; ripple, clear; no starring or fissuring of plate whatever; mold of shot-head perfect. At the rear of target, no practical damage whatever.

Round II—Against the same thickness of metal, but composed of 8 and 6 inch layers of armor, shot struck on the junction of the upper and lower face plates. Joint opened all along from one-fourth inch at end to 1¼ inches in the middle; neither plate starred nor fissured; no ripple on upper, fine ripple projecting 4 inches on lower plate. Diameter of shot-hole, 13 by 14 inches.

The behavior, then, of wrought iron under the impact of projectiles furnishes one of the best tests of its quality as a suitable material to resist penetration.

The great value of good wrought iron for armor plating lies in the fact that it does not transmit the shock to the adjoining parts of the structure, but absorbs the blow locally. The plates yield readily to penetration, to a certain extent, but they should not crack or break. Now, contrast what has been said regarding the qualities of good iron plates with the remarks in the foregoing table, under the column of "penetration," as to the behavior of the plates in the Wiard targets. In the first round with 15-inch Wiard rifle No. 1, giving a penetration of 15 inches, we read—

Plates very badly shattered, and two large pieces sent flying through the air.

In the first round of 15-inch Wiard rifle No. 2, with a penetration of 15 inches, it is noted:

First plate was broken up and scattered; hole in rear plate 30 inches in diameter.

In the second round, with same gun, giving a penetration of 12 inches—

All the plates through which the shot passed were broken.

In the third round, from same gun, giving a penetration of 12 inches—

Shot penetrated and broke up three plates; pieces of shot and plate scattered in all directions.

It should be here stated that these Nut Island experiments were made under the Navy Department, and an estimate may be formed of the importance which the Navy attach to them by the fact that it has completely ignored the so-claimed wonderful performances of the Wiard guns and projectiles.

The powder proposed by Mr. Wiard will give great trouble in making up into cartridges, and the cartridge frame required for it is a most serious objection, as reducing the necessary air-space in the powder chamber and thus occasioning high pressure on the gun. There is no novelty in the plan of perforating the powder grains with a central canal. Rodman experimented with perforated powder, and the German prismatic powder is made in that way. The latter powder, after years of experiment with perforated, regular formed, and very dense powder, has to-day reached a stage of perfection that it could scarcely be possible to equal with others which cannot be said as yet to have got so far even as the experiment stage. The Wiard powder does not possess any merit that cannot be claimed for the German primitive powder, but on the other hand the latter has been demonstrated to be in any way a practical suc-

cess, while the Wiard powder as yet belongs to the region of mere hypothesis. The supposition that the combustion of the grains will be confined to the inner surface and to the ends is sufficiently absurd, as the tension of the gas in the interior will almost immediately break up the grain into fragments.

H. F. MANN.

The breech system is heavy and cumbersome.

Weighs over three times as much as the corresponding parts of either of the two systems so much in use and so thoroughly tested.

These other systems are amply strong; hence much lighter guns can be used caliber for caliber.

Does not admit of such rapid maneuver.

Straps exposed to injury.

Requires the gun proper to be elevated and depressed at each fire instead of the simple and direct action of a block that is strong enough.

Getty Board did not object to *weight of gun*, as stated by Mr. Mann, but to weight of fermeture, for they say:

> The breech fermeture is held to the trunnions by heavy steel straps, the whole arrangement weighing 37,000 pounds. * * * This fermeture is the characteristic feature of the gun, and is the invention of Mr. Mann. The principal objection to it is its great weight, but, further, it necessitates the turning of the barrel of the gun on its trunnions through an arc of about 10° and back again at each discharge, requiring the expenditure of more time and force than for either the Krupp wedge or the slotted-screw systems. * * * In view of the objections set forth above to the fermeture itself—the specialty of Mr. Mann's invention—this Board fails to see sufficient reasons for recommending the gun for construction and trial.

The straps, transom, &c., *are absolutely* necessary to the fermeture or closing of the breech of the piece.

Mr. Mann's quotation, on page 35 of "statements," is not correct, or at least calculated to mislead. The "point" was not made by the Board against the gun itself, but against the breech arrangement, that is, against the entire mechanism necessary to close the breech and resist the shock of the discharge to the rear.

Reports that Mr. Mann quotes were all made many years ago, at which time his mechanism was new, and was considered worthy of trial; but *now* the world has got beyond it, and practical experience has given us systems that are light, simple, and superior to Mr. Mann's, and have been proved to be strong enough for all the work expected from high-power guns.

As guns are made to give admirable results with these simple systems, there is no necessity of resorting to any system against which serious objections can be justly raised.

WM. WHEELER HUBBELL.

Proposition that a heavy gun of high power be made of a special metal and cast solid should not be entertained, for, though Mr. Hubbell states that specimens have given high tensile strength, the metal has not been fabricated in sufficient quantities or in large enough masses to form a proper or correct estimate of its value for gun construction.

If it has been made in small specimens, experience in the casting of steel to which it is claimed this metal approximates has not reached a degree of perfection to warrant its use even in an experimental gun.

Simple casting not an advantageous method of making guns; much greater strength can be obtained by building up.

No necessity for using his metal for the smooth-bore guns or guns of moderate power, as proposed; for old cast-iron guns now on hand are being economically utilized by conversion for that purpose.

Breech mechanism not so strong or simple as those in use.

THEODORE YATES.

Projectile made of parts, hence lacks necessary strength for penetration; weak point comes where it should be strongest—*i. e.*, at base of head.

Means of giving rotation not so good as those in use which have been thoroughly and satisfactorily tried, and it is doubtful if it could be used at all with the increasing twist that we must have in high-power guns.

Breech-loading device is weak; would be difficult to fabricate. It would be difficult to obtain the close fit required in breech mechanism. Weakens the gun and affords no support in return, for proposed "shell" cannot be shrunk on the body.

Not applicable to the built-up system of construction, on which system modern guns must be made.

Apparently no good reasons can be urged for its success.

Getty Board say:

That the Board has examined the model, description, &c., of Mr. Yates' breech-loading ordnance, and is of the opinion that the breech-loading device does not possess sufficient merit to warrant its actual test.

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